

EXCLUSIVE!

INSIDE THE FBI'S BOMB LAB + RIDLEY SCOTT ON
THE MARTIAN PG. 42

POPULAR SCIENCE

OCTOBER 2015

The Future of Food

How to feed
a hungry
planet in the
digital age

Including vertical farms,
food computers,
push-button dinners,
drinkable meals & more!



GOOGLE'S
TOP-SECRET
X-LAB

SMART
GUNS

A DRONE
THAT FLIES
FOR YOU

KILLER
LASERS

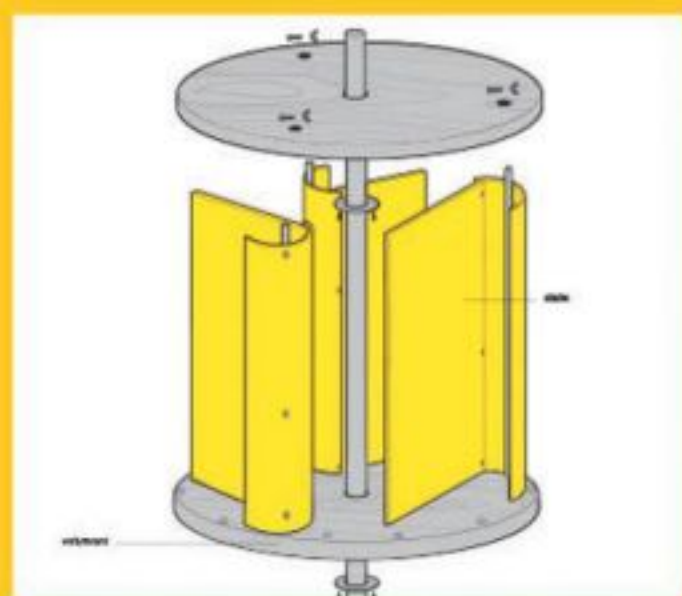
007'S
NEW RIDE



MAKE YOUR MARK!

Master 200+ Must-Know
DIY Tips and Tricks

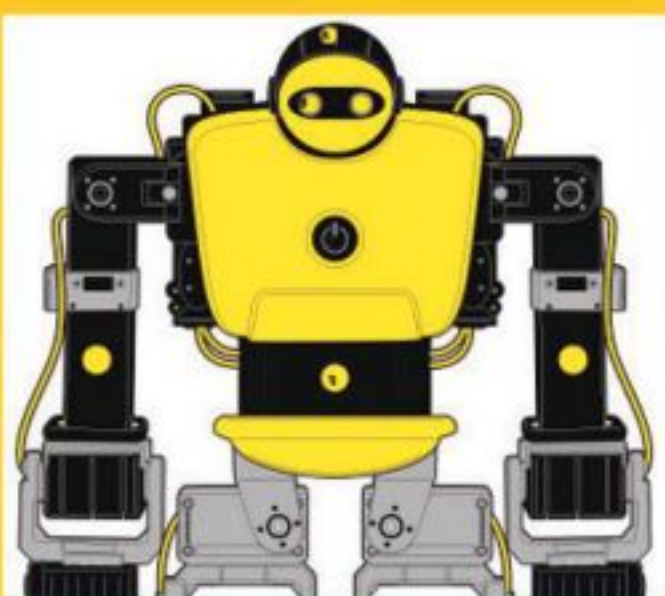
Popular Science delivers the step-by-step instructions and game-changing insights you need to transform a back-of-the-envelope idea into a gleaming finished product.



Generate power with a
DIY wind turbine!



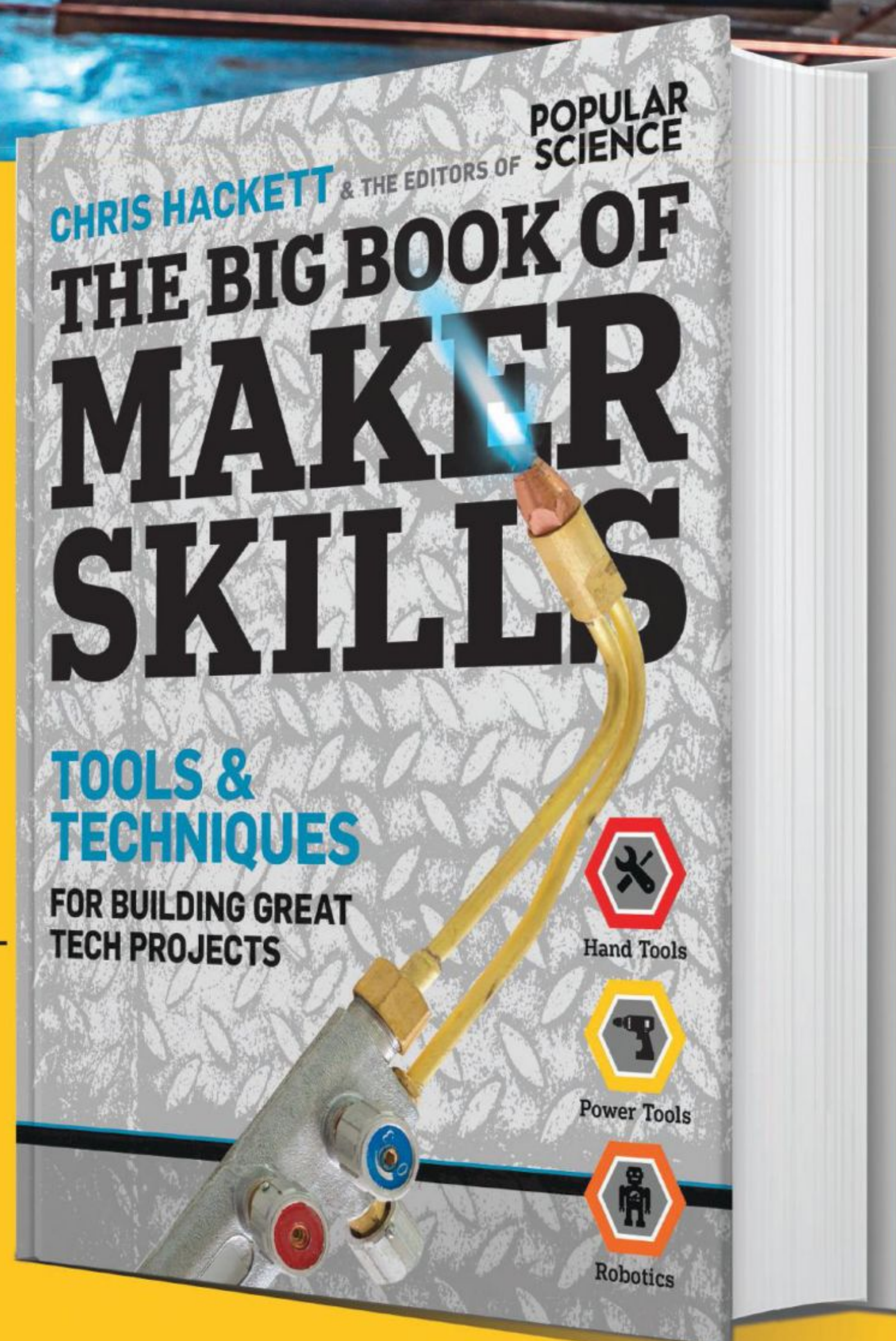
Cast a shot glass in a
brick!



Build your first 'bot,
from scratch.

Order your copy and
FREE LED FLASHLIGHT at

POPSCI.COM/MAKERBOOK





For daily updates: facebook.com/popsoci

OCTOBER 2015 • **FEED**

Volume 287 No. 4



34

THE FUTURE OF FOOD

How to feed a hungry planet in the digital age—no sunlight, soil, or pesticides required. (But there will be drones.)

PHOTOGRAPH BY SAM KAPLAN, FOOD STYLING BY SUZANNE LENZER; CORN COVER IMAGE: BURAZIN/GETTY IMAGES

Featuring

LET'S TALK ABOUT MARTIANS

We found the perfect excuse to geek out on exploring Mars. And we invited the director of *The Martian* to join us.

ERIK SOFGE

PAGE 42

BRILLIANT 10

For the 14th year, *Popular Science* honors the brightest young minds in science and engineering. They're networking cars, decoding the brain, preventing plagues—and they're just getting started.

VERONIQUE GREENWOOD AND CASSANDRA WILLYARD

PAGE 46

TO CATCH A BOMBMAKER

This is the story of a little-known FBI forensics lab and how it changed the global war on terror. **CLAY DILLOW**

PAGE 54

Departments

FEED

04 From the Editor

06 Peer Review

08 A Bit About Us

NOW

11 A drone that flies for you

12 Ten things we love this month

14 An exclusive look at 007's new ride

16 The best blender ever

18 Survival gear for enduring the elements

19 Turn your iPhone into a pro camera

20 Astro Teller on Google's moonshot lab

NEXT

23 Corals with colorful potential

24 Dick Rutan on the future of flying

26 A geek's guide to dark matter

28 Tour the natural world in a single tower

30 Smart guns leap from sci-fi into reality

32 Earth's biggest threat is us

MANUAL

61 Build a candle-free hack-o'-lantern

64 A 40-watt laser shotgun

65 Open-source genetic engineering

66 Use an electric toothbrush as a mini sander—not a tattoo gun

67 Sensors that work day or night

END MATTER

69 Ask Us Anything: Does coffee give you a different buzz than tea?

78 From the Archives

ON THE COVER

Tomorrow's corn will be increasingly high-tech. Illustration by Eric Heintz



From the Editor

The Revolution Will Be Green

In the waning days of World War II, a plant biologist named Norman Borlaug went south to Mexico. Ostensibly, he arrived there to teach modern farming methods at the behest of the Rockefeller Foundation. But Borlaug, described by most as a highly determined man, did much more than that: He started and led

perhaps one of the most profound revolutions the world has known.

The Green Revolution is a catch-all that describes advances in plant breeding, chemical fertilization, pest control, and irrigation, particularly from the late 1940s to the early 1970s. Those innovations—including Borlaug's contribution of high-yield short-stem wheat—helped grow agricultural productivity more quickly than the global population. And over a few decades that difference saved perhaps a

billion people from starvation and millions of acres of wildland from the plow. Borlaug won the Nobel Peace Prize for his work in 1970.

Today the world is in need of another green revolution. Gains in agricultural productivity have slowed or stopped in many places. Yet the global population steadily marches upward. According to the World Bank, the planet will need to produce 50 percent more food in 2050 to feed a population of 9 billion. At the same time, climate change

could trim existing crop yields by up to 25 percent. Food, along with water and energy, will be one of the defining issues of our time.

As we explore in this month's cover story, that next revolution is already afoot. Today farmers are using sensors, drones, and robots to monitor and tend to fields as precisely as possible, reducing waste and improving yields. Genetic engineers are creating and breeding plants more productive than even Borlaug could imagine. (I can almost hear the scribble of anti-GMO letters right now.) Seafood farms are sprouting up in Indiana, and even meat is being rethought. Can we 3D-print it? Pretty much. Just take a look at page 41.

In a sense, the revolution taking place today is an extension of

FOOD, ALONG WITH WATER AND ENERGY, WILL BE ONE OF THE DEFINING ISSUES OF OUR TIME.



Borlaug's movement but retooled for our digital age. Instead of mass production, today's buzzwords are efficiency and optimization. Like anything, this technology—lovingly called "agtech" by the startup set—has its limits. But if one thing has become clear to me in pursuing our feature, we haven't even begun to approach them.

Enjoy the magazine.

Cliff Ransom
Editor in Chief

Contributors



Clay Dillow

Each time Clay Dillow reports from the Pentagon or a massive agency like the FBI, he's surprised to find the place "made up of real people," he says. While reporting "To Catch a Bombmaker" (page 54), a scientist explaining the nuances of roadside bombs excused herself to go retrieve her puppy from the vet. The juxtaposition—from bomb tech to dog lover—says Dillow, was "humanizing."



Ilima Loomis

Taking on "The Search for Dark Matter" (page 26), was a no-brainer for journalist Ilima Loomis. "That a quarter of the universe can't be accounted for is irresistible," she says. Finding the stuff that holds our universe together is no easy task, but Loomis says they're getting close. In fact, she's already geared up for the next great piece of the puzzle to figuring out our universe: dark energy.



Alexander Wells

Alexander Wells learned plenty while illustrating our "Brilliant 10" feature (page 46). High on the list: the omnipresence of microbes in our lives. "They look amazing, but I fear I will never unsee how many bacteria live on everyday surfaces," Wells says. "By the end of it, I was worried that I was going to end up a germophobe like Howard Hughes!"



Suzanne Lenzer

To gather material for "The Future of Food" (page 34), stylist Suzanne Lenzer found herself at a farm in Bushwick, Brooklyn, where lettuce grows in water tanks. Lenzer has been known to wax poetic about heirloom tomatoes, but when she saw the lettuce, she raved. "These hydronic heads had stunningly beautiful white root structures," she says. Some foods just bring out the nerd in us all.

SIGMA

BONA-FIDE.

The lens for the high mega-pixel era.

A large aperture standard lens delivering outstanding resolution, exquisite images with beautiful bokeh. A bona-fide classic.

A Art 50mm F1.4 DG HSM

Case, hood (LH830-02) included.
USA 4 Year Service Protection



SIGMA USB Dock

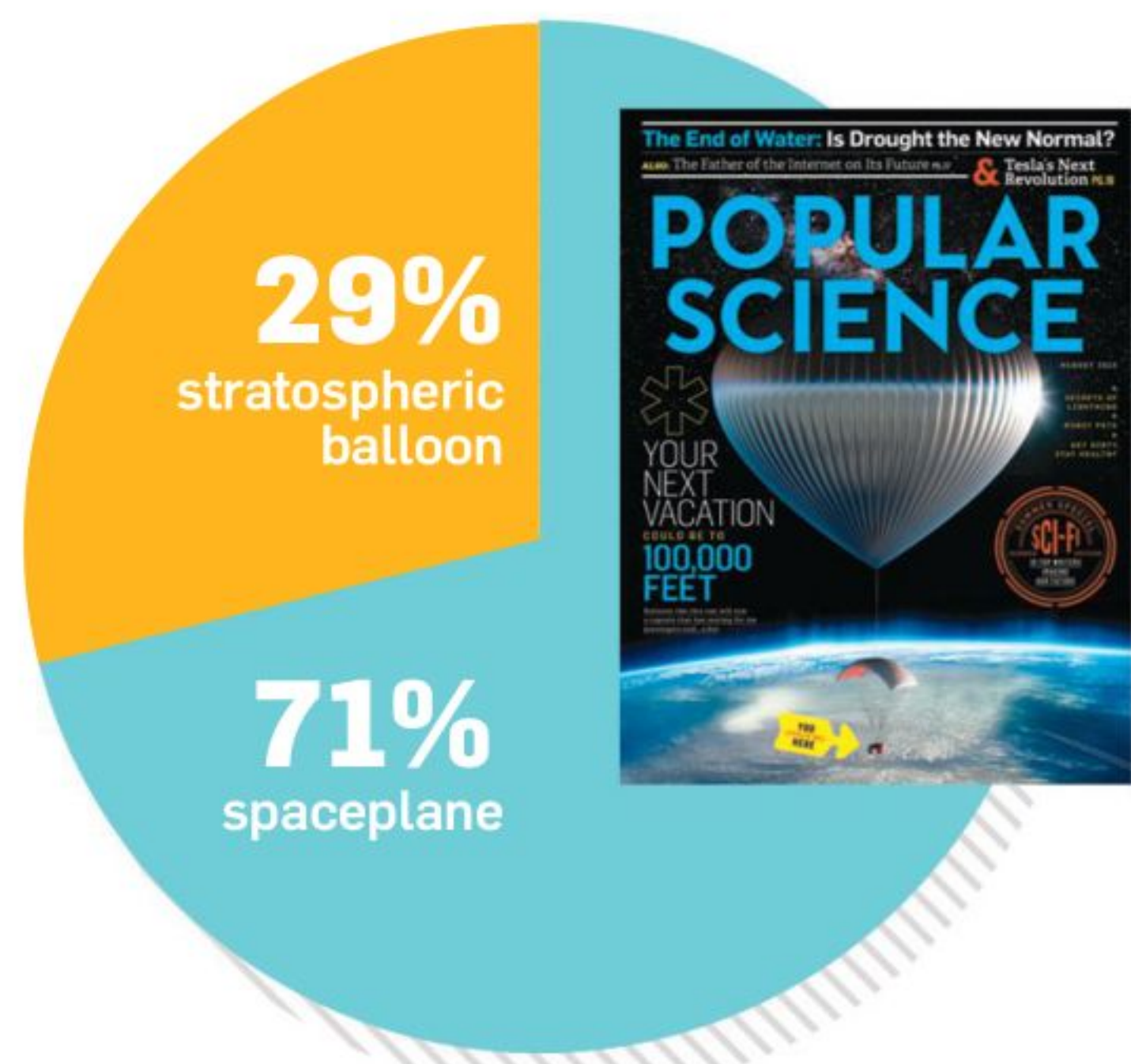
Update, adjust & personalize. Customization never thought possible. Sold separately.



Peer Review

FOR THE THRILL

Last month, we asked readers which type of transportation they would take to the edge of space if offered a seat: spaceplane or stratospheric balloon? Looks like we've got some adrenaline junkies out there.



ADHIRAJ MATHUR I would choose the spaceplane because it's closer to the experience a real astronaut might have.

STEPHEN BEETS Spaceplane. It's WAY faster and more flexible in terms of mission capabilities than any balloon.

ELYSE DORM Balloon, but preferably if it's done like that first guy did it, floating up by yourself in a space suit, and then catapulting back to Earth when you're done. That would be fantastic!

JOB INSECURITY

My grandfather, retired U.S. Air Force Col. Dan Delton Fulgham, was an Air Force master balloonist in the 1950s. He would take balloons to the upper limits of the atmosphere and then parachute out, testing the rudimentary space suits of the era. Your article ["Wish You Were Here," August 2015] reminded me of his experiences.
Matt Fulgham, Richardson, Texas

BAR NONE

I really like the idea of cruising to an altitude of 20 miles in a balloon ["Wish You Were Here," August 2015], however, I think the in-flight bartending service should be scrapped. The money saved could be used toward providing those aboard with light pressure suits and parachutes. A cabin decompression at 100,000 feet would be catastrophic.
Glenn W. Knox, Jacksonville, Florida

TWEET OUT OF CONTEXT

Obviously aliens...
@GavanBoucher



MAN'S BEST FRIEND?

In the article "Robot Pets Have a Leg Up on Fido" [August 2015], we examined the idea of robotic companion animals. They wouldn't need to be fed, wouldn't soil the house, and could be left alone. But could humans bond with them? Our Facebook readers seemed more open to the notion than we expected.

RICK WAINIO Humans bond with anything that looks cute and acts like it could have self-awareness, so yes.

NAVIN KUMAR Humans can bond with machines, no biggie. Trick is for machines to bond with humans.

TONY CARLYLE Sure! I couldn't do without my smartphone.

CHRISTOS KYRIACOU The bond already exists between us and our computers, our iPads, our phones. The bond between us and any robot will be much easier to forge.



HAVE A COMMENT?
Write to us at
letters@popsci.com or
to *Popular Science*
2 Park Ave., 9th floor
New York, NY 10016

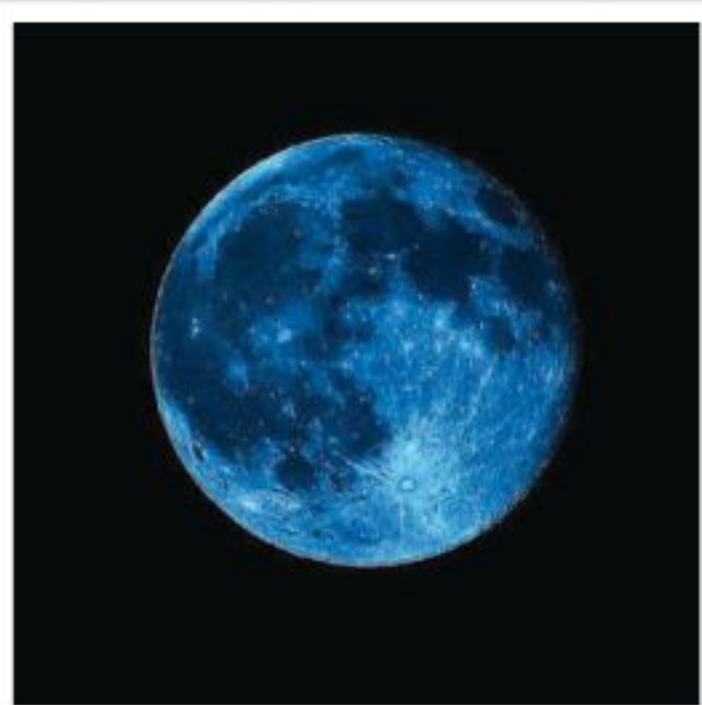
SHOW & TELL

ONCE IN A BLUE MOON

At the end of July, we held an Instagram contest in which we asked followers to post their best photos of that month's blue moon; it occurred on the 31st. These three winners were chosen based upon clarity and composition.



@PASSMOTION, Turkey



@ALBIEMO, California



@ADAMKSTOREY, Pennsylvania

POPULAR SCIENCE

Why should you sign up for our newsletter?

REASON
#32

Our perspective on science is unique. Like you.

Sign up for the *Popular Science* editorial newsletter and each week you'll get the latest and greatest in tech reviews, science news, video, photography, and special offers.



**GET THE
LATEST
CONTENT
FROM OUR
DIGITAL
EDITIONS**



Available on the
App Store

THE FUTURE NOW

PopSci.com's news-reader app delivers all the content from PopSci.com in an easy-to-read format on the go.



Available on the
App Store

Get up-to-the-minute news on cutting edge scientific research, gadgets and green tech. Save the stories to read, even when you're not connected, and filter them by your favorite topic.

STAY CONNECTED TO THE POPULAR SCIENCE COMMUNITY



Sign up today:

POPSCI.COM/NEWSLETTER



A Bit About Us

♥ Follow us on twitter @popsci



ZOMBIE SCIENCE

Excited for season six of *The Walking Dead*? We are too. Actor Ross Marquand (you know him as Aaron) will talk all things zombie apocalypse this month at popsci.com.

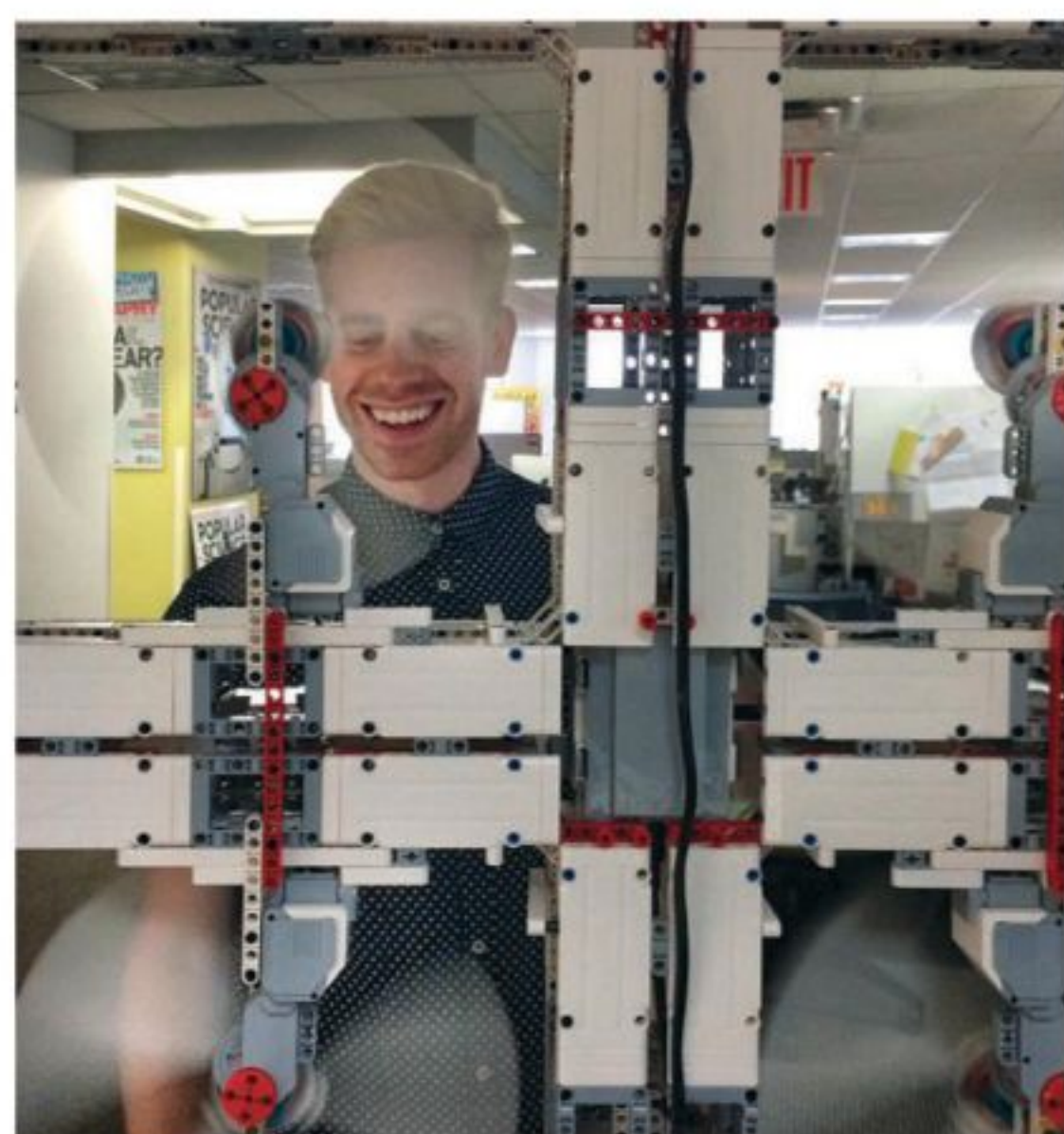
HEAR THE FUTURE



In July, we launched a podcast called Futuropolis. This month we wrap up our first season. If you've ever wondered what finding love, communicating, or buying a sandwich will be like in the future, be sure to check it out on iTunes, SoundCloud, or your favorite podcast app.

TIME WARP

Students at Friendswood High School in Friendswood, Texas sealed a time capsule in May. It included 11 issues of *Popular Science* (along with devices like an e-reader and a smartphone). The school's librarian Pat Torre Franca describes the choice of contents: "Twenty-five years from now, when the capsule is opened on our school's 100th anniversary, these items will elicit nostalgia, wonder, thought."



KEEPING COOL

LEGO brought the Technic Wall of Fans to the *Popular Science* office this summer. The motion-activated fan wall is built with Mindstorms motors and sensors and Technic blocks. It's more work than AC, but more gratifying.

For reprints, email: reprints@bonniercorp.com.

FOR CUSTOMER SERVICE AND SUBSCRIPTION QUESTIONS, such as renewals, address changes, email preferences, billing, and account status, go to popsci.com/cs. You can also call 800-289-9399 or 515-237-3697, or write to *Popular Science*, P.O. Box 6364, Harlan, IA 51593-1864.

EDITOR IN CHIEF Cliff Ransom
Design Director Todd Detwiler
Executive Editor Jennifer Bogo

EDITORIAL

Managing Editor Jill C. Shomer
Editorial Production Manager Felicia Pardo
Articles Editor Kevin Gray
Information Editor Katie Peek, Ph.D.
Technology Editor Michael Nuñez
Projects Editor Sophie Bushwick
Associate Editors Breanna Draxler, Lois Parshley
Assistant Editors Matt Giles, Lindsey Kratochwill
Editorial Assistant Grennan Milliken
Copy Editor Cindy Martin
Researchers Rebecca Geiger, Erika Villani
Editorial Interns Dave Gershgorin, Rebecca Harrington, Levi Sharpe

ART AND PHOTOGRAPHY

Photo Director Thomas Payne
Digital Associate Art Director Michael Moreno
Designer Zachary Gilyard

POPULARSCIENCE.COM

Online Director Carl Franzen
Senior Editor Paul Adams
Assistant Editors Sarah Fecht, Claire Maldarelli
Producer Joey Stern
Contributing Writers Kelsey D. Atherton, Mary Beth Griggs, Alexandra Ossola

CONTRIBUTING EDITORS

Brooke Borel, Tom Clynes, Clay Dillow, Nicole Dyer, Daniel Engber, Tom Foster, William Gurstelle, Mike Haney, Joseph Hooper, Corinne Iozzio, Gregory Mone, Adam Piore, P.W. Singer, Erik Sofge, Kalee Thompson, James Vlahos, Jacob Ward

BONNIER TECHNOLOGY GROUP

Group Editorial Director Anthony Licata
Vice President, Publishing Director, New York Gregory D. Gatto
Chief Marketing Officer Elizabeth Burnham Murphy
Financial Director Tara Bisciello
Eastern Sales Director Jeff Timm
Northeast Advertising Office Margaret Kalaher, Matt Levy
Midwest Managers Carl Benson, Doug Leipprandt
Ad Assistant Lindsay Kuhlmann
West Coast Account Managers Stacey Lakind, Sara Laird O'Shaughnessy
Detroit Advertising Director Jeff Roberge
Direct Response Sales Shawn Lindeman, Frank McCaffrey, Chip Parham
Advertising Coordinator Nicky Neddo
Digital Campaign Managers Amanda Alimo
Digital Campaign Coordinator Justin Ziccardi
Group Sales Development Director Alex Garcia
Senior Sales Development Manager Amanda Gastelum
Sales Development Manager Charlotte Grima
Creative Services Director Ingrid M. Resmaier
Marketing Design Directors Jonathan Berger, Gabe Ramirez
Marketing Design Manager Sarah Hughes
Digital Design Manager Steve Gianaca
Group Events & Promotion Director Beth Hetrick
Promotions Managers Eshonda Caraway-Evans, Lynsey White
Consumer Marketing Director Bob Cohn
Public Relations Manager Molly Battles
Human Resources Director Kim Putman
Production Manager Erika Hernandez
Corporate Production Director Jeff Cassell
Group Production Director Laurel Kurnides

BONNIER

Chairman Tomas Franzén
Chief Executive Officer Eric Zenczenko
Chief Operating Officer David Ritchie
Chief Marketing Officer Elizabeth Burnham Murphy
Chief Digital Revenue Officer Sean Holzman
Vice President, Integrated Sales John Graney
Vice President, Corporate Administration Lisa Earlywine
Vice President, Consumer Marketing John Reese
Vice President, Digital Audience Development Jennifer Anderson
Vice President, Digital Operations David Butler
Vice President, Public Relations Perri Dorset
General Counsel Jeremy Thompson



This product is from sustainably managed forests and controlled sources.

5 Proven Ways to Get Better Protection for Your Home

How to get protection and avoid getting ripped off—recommended by Tech Experts, Personal Finance Wizards, and Authorities in Home Security

1 Make sure it's wireless.
“Wired” alarms are vulnerable—a burglar can snip one wire and shut down your whole system. A wireless system protects your home even if a burglar cuts your power.

2 Compare monthly fees.
Many home security companies will charge you outrageous fees of over \$50 per month. It's possible to find the exact same protection for less.

3 Look for U.L. Listed
professional monitoring to send the police if there's an emergency at your house. U.L. Listed means the monitoring centers are rigorously inspected every 6 months to ensure you get the highest caliber of protection.

4 Watch out for sneaky “Gotchas.”
They're usually buried deep in the fine print of a home security contract. Here's an example from a real home security company's contract:

3. INCREASE IN CHARGES.
[REDACTED] has the right to increase the annual service charge at any time after the first year.

5 Whatever you do, don't sign a long-term contract. Home security contracts make it impossible to cancel. You get locked in for 3 years (or more) and committed to thousands of dollars in payments.

Experts Recommend: SimpliSafe Home Security. A new award-winning wireless security system. CNET calls it, “Better, Smarter Home Security.”


SimpliSafe™



Protect your home the smart way

- Provides U.L. Listed professional monitoring
- Protect your home for just \$14.99/month
- No long-term contracts locking you in.

Popular Science Readers
get an exclusive **10% off** at

[SimpliSafe.com/sci10](https://www.simplisafe.com/sci10)

Thank you for being a subscriber!

Our iPad edition is now included in your print subscription.



How to claim your iPad subscription:

1. Download the free Popular Science app from the iTunes app store if you have not done so already.
2. Open the app and tap the "My Account" button on the bottom of the front page.
3. Tap the bar that says "Current Print Subscribers – Digital Access".
4. Use one of the 3 options to enter the information associated with your subscription, as requested.
5. You will receive a password sent immediately to your e-mail address.
6. Press the Rotary symbol in the upper right corner of the app front page to sign in using your e-mail address and the password you were just sent. You will be able to access your digital issues immediately. You may change your password as you choose after signing in.

To start a new subscription to Popular Science, go to
www.popsci.com/subscribe

Apple, the Apple Logo, and iTunes are trademarks of Apple Inc., registered in the U.S. and other countries. iPad is a trademark of Apple Inc. App Store is a service mark of Apple Inc.



A Drone That Flies and Films for You



Shooting aerial footage from a drone is tricky. Pilots have to worry about throttle, pitch, yaw, and roll of the drone. When filming, they also need to consider camera focus and gimbal axis. The 3DR Solo Drone automates those chores, leaving you



3DR SOLO DRONE

Price \$1,000

Weight

3.3 pounds

Flight Time

25 minutes

Max Speed

55 mph

Max Range of

Live Video

0.5 miles

free to take killer shots of any scene.

With more than a dozen presets, the drone can fly in a circle, glide between two points, follow a person on the ground, and loop away from you for a selfie—all from its app and all with the push of a button. It is also the first drone to stream HD video from a GoPro camera, letting you monitor the live feed from any smartphone or tablet.

A gaming-inspired controller, with a trigger at the top of the controller, lets you fly the Solo Drone up to 400 feet (the most allowed by

federal regulators). It's out-of-the-box flyable, so any novice can take professional-looking photos. But the Solo's biggest advantage—over close competitors like DJI's Phantom 3—might be its open-source upgrades.

Dronemaker 3DR has opened its app to developers so they can create software hacks and accessories. For instance, a ballistic parachute might be deployed in an emergency (so your drone doesn't crash back to Earth). Now you just need to find a subject worthy of your Oscar ambitions.

REBECCA HARRINGTON





Obsessed

Some things are just...better

LINDSEY KRATOCHWILL

1 ROBO-SAUCE

This children's picture book from Adam Rubin and Daniel Salmieri follows a young boy who tries a neon concoction called Robo-Sauce. It (predictably) turns him into a robot. Things go south when his parents and dog transform too. **\$19**

2 KNOCK KNOCK

This app, available for iOS and Android, uses Beacon technology to share whatever contact information or social-media handles you choose by knocking on your phone. It also builds chat rooms of nearby users. **Free**

3 BLUESMART LUGGAGE

Bluesmart is the Swiss Army knife of carry-on suitcases. Bluetooth location tracking ensures it won't go missing. A built-in scale keeps you from maxing out weight limits, and USB chargers keep your phone alive. **\$495**

4 TOPO COASTERS

Set your sweaty glass down on your favorite topographical regions with these cork coasters. The first set features Kentucky's Red River Gorge. Map coordinates are engraved on the reverse side in case you want to see the real thing. **\$39 for four**

5 M18 FUEL BRAKING GRINDER

Milwaukee has the first grinder tool that lets you make cuts and grind edges on battery power alone. Releasing the trigger stops the spinning wheel within two

seconds. Combined with a kickback reducer, it's a safety perk, and it gives the tool a longer life. **\$219**

6 DISNEY PLAYMATION

Playmation outfits kids with superhero gear to explore and carry out missions as their favorite character. It's made all the more realistic thanks to motion sensors and wireless tech. The first set released this month is based on *The Avengers*. **\$120**

7 E1 4K ACTION CAMERA

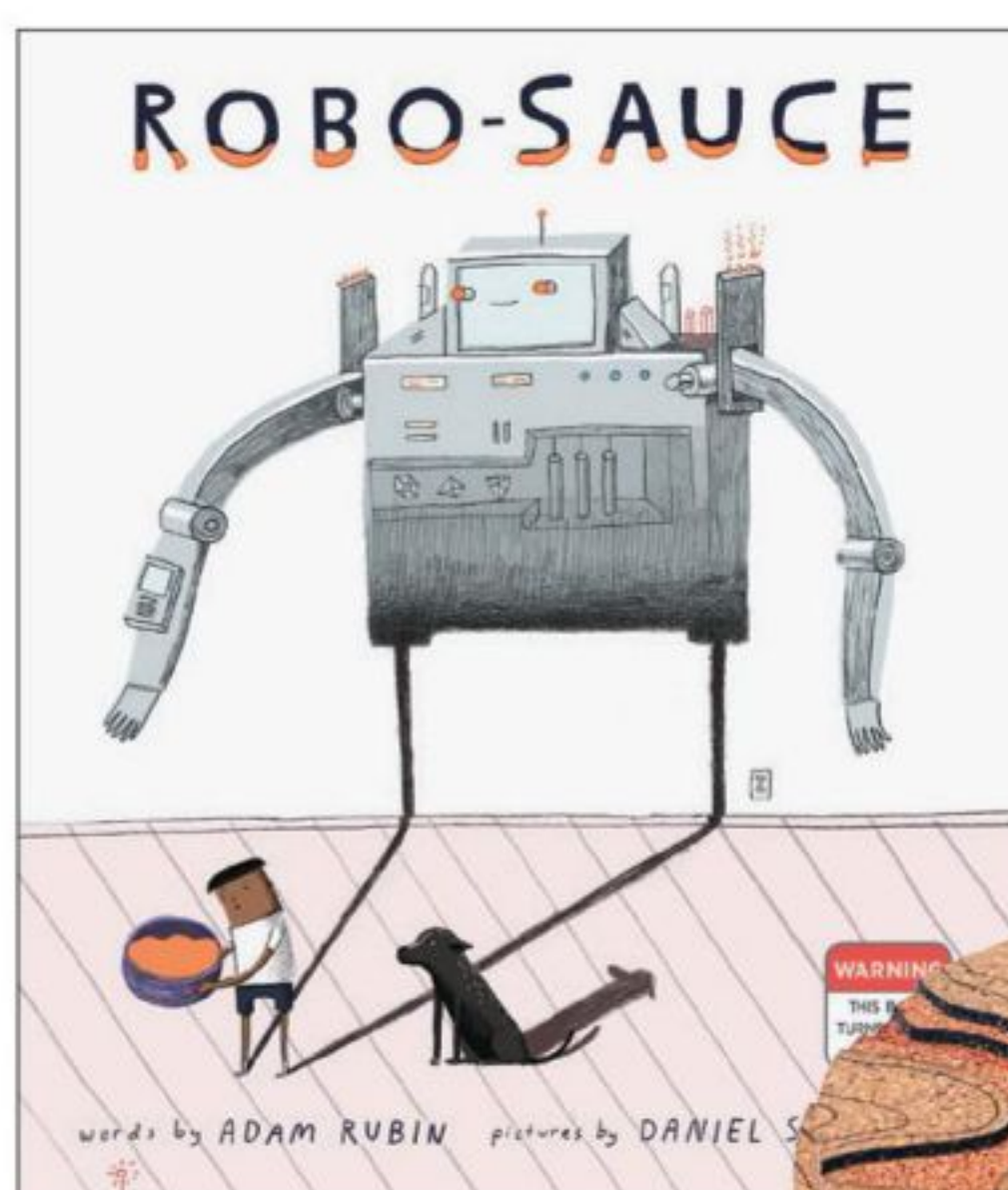
Digital imaging startup Z created a tiny camera to give documentarians and athletic auteurs more control than your average action camera. It has interchangeable lenses, can film in 4K at 24 frames per second, and has a 3-D noise filter for low-light scenes. **\$699**

8 ZOLT CHARGER PLUS

Laptops are great, but that brick you have to carry to plug it in and charge can be burdensome. Zolt packs power into a 3-ounce tube. Plus it has two extra USB ports that can charge other devices at the same time. **\$100**

9 LECHAL

Stop navigating a new city staring at a smartphone. Lechal's shoes and insoles vibrate to guide wearers to their destination. Plus, each pair you purchase subsidizes a pair for someone who's visually challenged. **From \$80**



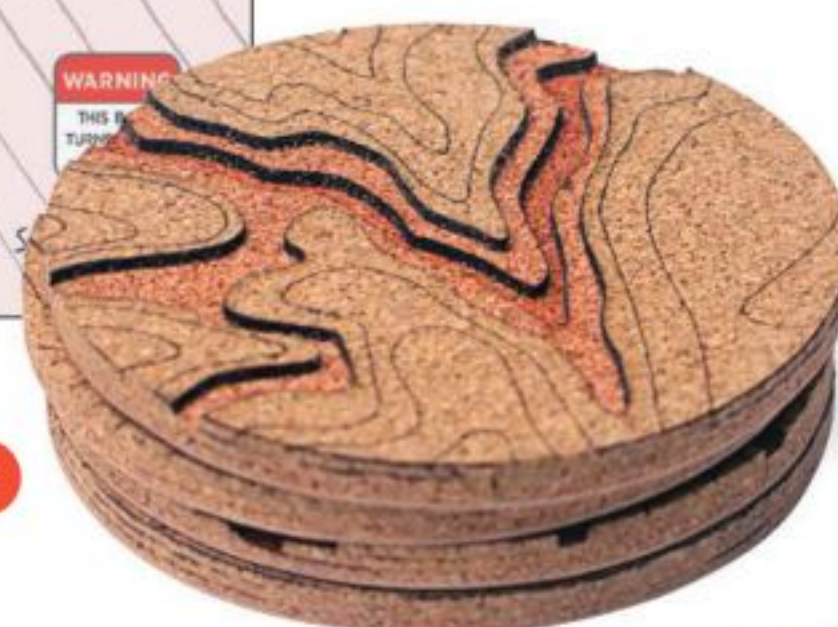
1



2



3



4



5



6



7



8



9



10 STEVE JOBS

Danny Boyle's new film riffs on Walter Isaacson's biography of Apple's co-founder (played by Michael Fassbender). Go behind the scenes of Apple's product announcements, starting with the iMac. **October 9**



JUST ASK

*Add gelato to
my shopping list.*

How is traffic?

*What's on my
calendar today?*

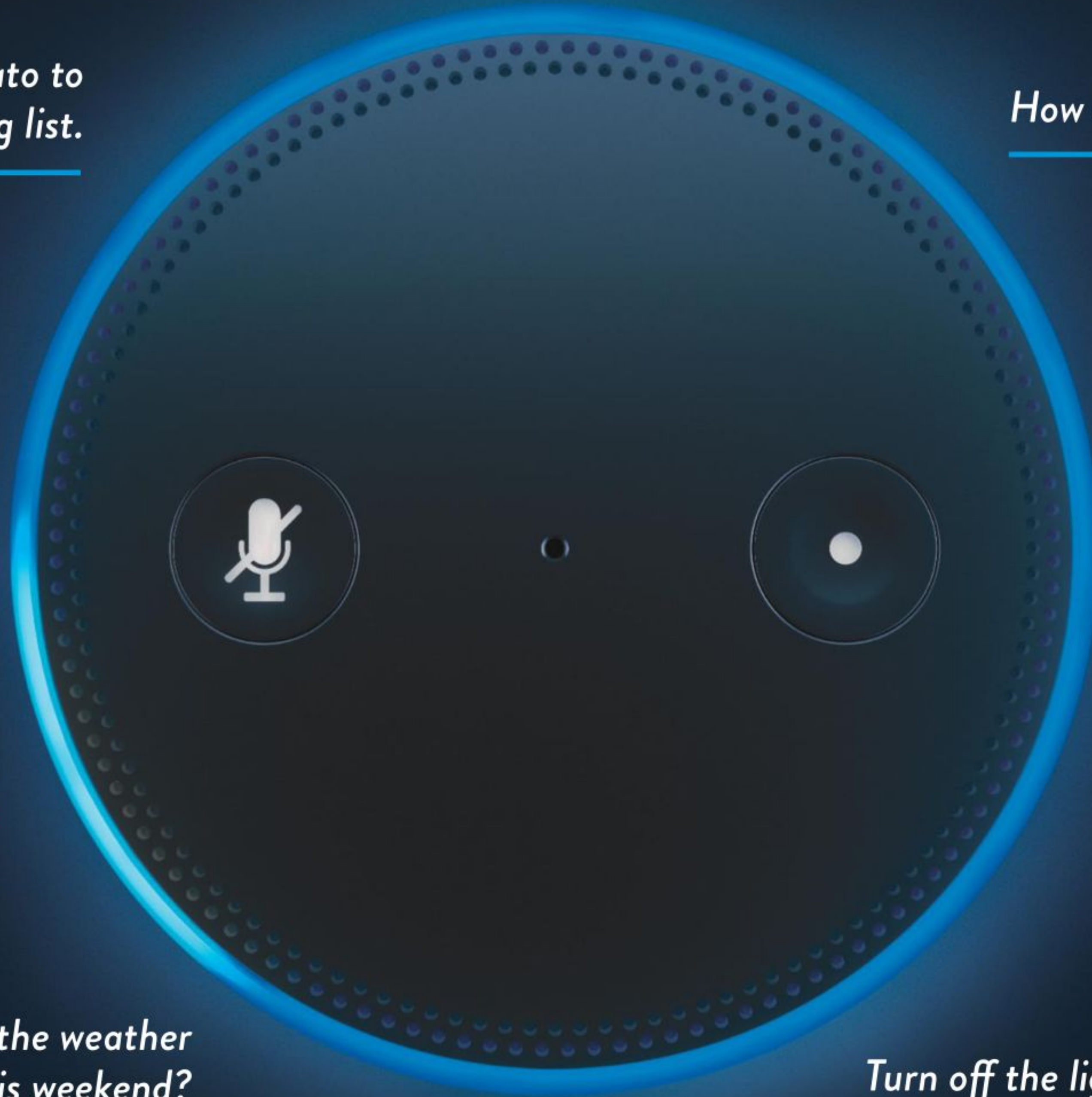
*Set a timer
for 3 minutes.*

*Play my "New
Artists" Playlist.*

*What's the
news today?*

*What's the weather
like this weekend?*

Turn off the lights.



Amazon Echo is designed around your voice. It's hands-free and always on to answer questions, play music, read the news and check sports scores, traffic, the weather and much more. **Just ask.**

INTRODUCING
amazon echo



The Real Star of the James Bond Movie



Hollywood director Sam Mendes doesn't usually design high-performance sports cars. But he made an exception for James Bond. Mendes, who directed the latest 007 franchise film (in theaters November 6), worked with legendary auto designer Marek Reichman to create the movie's signature vehicle: the Aston Martin DB10. Their aesthetic goal: "It had to have the look of the character driving it," says Reichman, Aston Martin's chief creative officer. "It had to have a predatory nature."

ASTON MARTIN DB10

0-60 Speed
4.7 seconds
Engine
4.7 liter V-8
Top Speed
190 mph
Number Produced
10

And it had to be (almost) one of a kind. Though Aston Martin has been building Bond's cars over the course of 25 years, this is the only one that won't eventually hit the production line. As its name implies, the DB10 is a limited run of 10 state-of-the-art concepts. Reichman's engineers tailored each car to its scene. Some have roll cages. Some have flamethrowers in the exhaust. Plot spoiler: It's disguised in such a way that it will surprise audiences. "We had to make the design imperceptible," Reichman says.

Of course, even Bond's previous consumer-ready Aston Martins didn't come with flamethrowers. The genius of these concept cars is that they are harbingers of what's to come to the market. The DB10 shares a burly posture with Aston Martin's One-77, a previous concept car, but its longer wheelbase gives it a stout, grippier stance. Beneath its

skin, it incorporates the carmaker's three-year-old, 420 hp Vantage coupe, employing the same 4.7-liter V-8 engine. And in a first for Aston Martin, the DB10 has acquired LEDs for headlights, giving it a thin, sharp, menacing stare. The LEDs also have a practical benefit. They shave weight off the front end and make it lighter. Any time you can take advantage of reducing mass, that has a performance advantage," says Reichman, who also designed the company's first \$2 million car—the limited-edition (24 in all) track-only, 12-cylinder, 800 hp Vulcan hypercar.

That car you can buy. The DB10 you can't. "There will be so many people asking: 'Can I have one? Can I have one?'" says Reichman, who won't divulge the car's production cost. "But there's only one person who can have this car and drive it. And that's 007."

JOSEPH OROVIC

"There will be many people asking if they can have one...but there's only one person who can drive this car."



NEW

**Straight
Talk**
wireless

Place your phone
here to cut your
wireless bill in half**

NOW WITH 5GB OF HIGH-SPEED DATA

Bring your own phone to Straight Talk and get unlimited talk, text and data with the first 5GB of up to 4G LTE[†] data for just \$45 a month. With a simple switch of a SIM card, almost any phone can be a Straight Talk Wireless phone. Keep your phone, network, and number for half the cost.** Learn more at StraightTalkBYOP.com

\$45 NO-CONTRACT 30-DAY PLAN
UNLIMITED
TALK • TEXT • DATA
FIRST 5GB HIGH SPEED
THEN 2G*

** "Cut your bill in half" and "Save up to half the cost" are based on a service comparison of the two largest contract carriers' monthly online prices for comparable individual post-paid contract service plans, including overage charges, and Straight Talk's \$45 service plan. Excludes the cost of the phone and limited time promotions. Source: Contract carriers' websites, July 2015.

† To get 4G LTE speed, you must have a 4G LTE capable device and 4G LTE SIM. Actual availability, coverage and speed may vary. LTE is a trademark of ETSI.

* At 2G speed, the functionality of some data applications such as streaming video or audio may be affected. All currently active Straight Talk BYOP customers will also receive the first 5GB Data at High Speeds at the start of their next 30 day cycle. Please refer always to the Terms and Conditions of Service at StraightTalk.com

Only at
Walmart

How It Works

Angling for a Perfect Blend



When choosing a blender, most people focus on speed. The logic goes: The faster blades spin, the better they pulverize fruits and vegetables, and the better the resulting smoothie, soup, pesto, or cocktail. Not so, say the engineers at Electrolux. Too much force crushes seeds, which busts them open and releases enzymes that make for a bitter taste. So, instead of designing a faster motor, the company tilted the canister. The angle creates an irregular funnel within the mixture, allowing the food to circulate evenly. And, they've employed titanium-coated blades of different shapes and purposes to thoroughly process it. The result is better texture and taste, with half the speed.

CORINNE IOZZIO



ANGLED CANISTER

Engineers tilted the canister about 5 degrees from its vertical axis, which mimics the way a chef holds a mixing bowl to whip eggs or batter. The angle creates more turbulence in the funnel, circulating food around as well as up and down. This ensures that all ingredients receive equal attention from the blades below.

OFF-CENTER MOTOR

The 1,200-watt motor is pitched about 5 degrees off-center from the canister, which further agitates the flow of ingredients within the funnel.

LIFTING BLADES

S-shaped blades sweep the canister's sides and bottom, lifting pieces of food up and toward the other blades.

FINE-CUT BLADES

The shorter, thinner, upwardly angled blades slice open tough skins, like those on apricots.

CRUSHING BLADES

A pair of straight, blunt blades smashes hearty flesh, like that of carrots and potatoes. Since all the blades spin at about 10,000 RPM—roughly half the speed of popular high-speed blenders—they don't crack seeds.

TASTE TESTED: SPEED VERSUS DESIGN

Is the Electrolux's Masterpiece Collection blender better than a high-speed Vitamix blender? We ran a side-by-side taste test with a kale-and-fruit smoothie (the juice drinkers' poison of choice). Here's what we found:

ELECTROLUX MASTERPIECE COLLECTION JUG BLENDER

After a 45-second blend, the drink was perfectly smooth, and free of chunks that might clog a straw. Better yet, every sip tasted the same—the product of thorough mixing.

VITAMIX 7500

With a max RPM of 37,000, the blender successfully mashed all the juice's 11 ingredients. But it left a few macerated pieces of fruit behind, resulting in uneven texture and flavor. Confession: We re-processed this blend in the Electrolux post-test to enhance the drinkability.

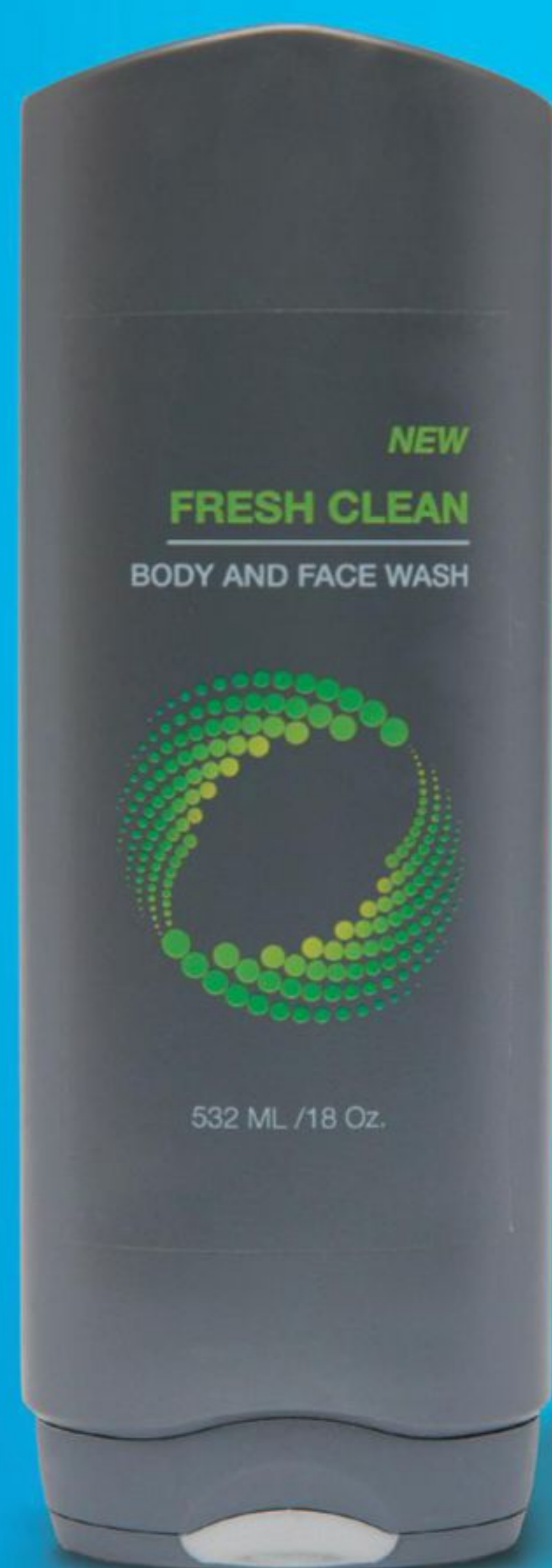


ELECTROLUX MASTERPIECE COLLECTION JUG BLENDER

Speeds 3
Max capacity 74 ounces
Max RPM 10,000 (approx.)
Price \$349



*“I want
to be
a comb.
Recycle me.”*



 IWantToBeRecycled.org



KEEP AMERICA
BEAUTIFUL

The Setup

Make It Out Alive

Three essential tools to conquer the wild (or weather the End Times)

MICHAEL NUÑEZ



1 KNIPER MULTITOOL

Throwing knives are usually made for one purpose: to be hurled end over end until they embed in a wood surface. (Thwack!) The Kniper is fun like that, but it also adds 22 important functions, including a fork, range finder, pry bar, sundial, wire stripper, wrench, saw, bottle opener, and screwdrivers. The Kniper is milled from high-carbon steel and is finely balanced, so it's easy to hit your target. Oh, yeah: It also has a tobacco pipe (in case you haven't kicked the habit yet). **\$145**

2 BREITLING EMERGENCY

Pilots, anglers, and backcountry trekkers often carry personal locator beacons to send distress signals if something should go wrong. Breitling's engineers have encased one in a watch. The Emergency can transmit to the international Cospas-Sarsat system, which has saved more than 37,000 lives worldwide since 1979. **\$16,475**

3 VSSL FLASHLIGHT

At night, it's easy to take the wrong step. The VSSL flashlight's super-bright LEDs lead the way and can last more than 20 hours. It also holds lip-balm-size canisters for gear like a fire-starting kit, trail markers, a first-aid kit and, our favorite, an emergency tent. **\$100**

Clip a Pro Camera to Your iPhone



Say you're at a concert and you want to shoot footage. Smartphone image sensors can't handle the low light or rapid action. The DxO One offers snap-on clarity. It attaches to your iPhone, and takes high-resolution photos and video.

The size of a stack of business cards, the DxO One clips onto an iPhone's Lightning connector, so there's no need for complicated Bluetooth pairing. You can select

shutter speeds and play with depth-of-field aperture settings, something found only in high-end compact cameras and DSLRs. It also runs off its own battery, so it won't drain your iPhone's charge. You can store photos on the phone or to a MicroSD card, and share photos and video straight to your favorite social-media channel.

DxO is known by professionals for its camera sensor rating system, and this is its first entry into the market it covers. It just so happens the company awarded itself a top rating, placing the DxO One among the best (and most expensive) cameras out there. For quick-draw shooters, it's a handy addition to the kit. DAVE GERSHORN



DXO ONE
Video Resolution
 1080p / 30 fps
Sensor Size
 1" (13.2x8.8mm)
Focal Length
 32mm (full-frame equivalent)
Aperture
 f/1.8 adjustable down to f/11
ISO Range
 100 to 51,200
Photo Resolution
 5,406-by-3,604 pixels
Price \$599

PHOTOGRAPH BY JONATHAN KAMBOURIS

COMFORT & LOOKS ARE FINALLY ON THE SAME TEAM

©2015 VF Jeanswear Inc.

Lee®

----- Est. 1889 -----

**COMFORT NEVER
LOOKED SO GOOD**

**PREMIUM FABRIC
MORE FLEXIBLE
SOFTER AND STRONGER**

MADE WITH



ACTIVE COMFORT DENIM

New Lee jeans are available at
JCPenney®, JCPenney.com and Lee.com

Mike Golic
MIKE GOLIC

Mike Greenberg
MIKE GREENBERG



GOOGLE [X]'S ASTRO TELLER SEES THE FUTURE

If only he'd tell us what it is.

EDITED AND CONDENSED BY MICHAEL NUÑEZ
PHOTOGRAPH BY CODY PICKENS



In August, Google made the surprise announcement that it was changing the company's name to Alphabet. Under the new structure, the money-making advertising business was separated from its loftier moonshot projects such as Google Glass, self-driving cars, and Internet delivery balloons. Astro Teller, who heads Google[x], the division that oversees those projects, spoke to *Popular Science* days before the news broke. He talked about the skepticism investors have over long-shot projects, why such projects are necessary to Google's survival, and how he culls the winners from the losers.

Popular Science: How do you vet moonshot ideas?

Astro Teller: We probably look at 1,000 ideas, for a few hours each, for every self-driving-car project we end up with. So it depends on where the project's Achilles' heels are. If it has only one Achilles' heel, it can take a long time to find it. If it has many, you can find one quickly.

PS: Give me an example.

AT: Yesterday I was in a room with 30 people discussing a potential new project, and they were pitching their hearts out. And frankly, they had me excited. The idea had to do with the ocean. And they were telling me why it was going to be important. Eventually I said: "Look, I'll give you three choices: Between sharks, storms, and pirates, which is the most likely to kill this project?" Everyone started laughing—not because I was kidding, but because that question sounds funny and yet was totally appropriate.

I didn't want to find out in a year from now this idea wasn't going to work because of pirates.

PS: What was the idea?

AT: I can't tell you. And I realize that's why we're often painted as a secretive organization. But that's not our intention. I want to be able to kill

by Google with producing long-term results. Like all other parts of Google, we are held to the standard of producing value. But we still aspire to a strong return on investment. We don't take on Google Glass or the self-driving-car project or Project Loon unless we think that on a risk-adjusted basis, it's worth Google's money. But

"Between sharks, storms, and pirates, which is the most likely to kill this project?"

projects as fast as possible with as little emotional baggage as possible. One of the rate-limiting issues of innovation is that people have a hard time killing their projects. So the more we are publicly committed to a project, the harder it becomes for us to kill it. If I tell you we're making a space elevator or an anti-gravity machine, and then next week we find a flaw in the idea, people would resist ending the project partly because the public has gotten excited about it. So it's not that we don't want to share it with the public. We just want to be sure of our thesis before taking victory laps.

PS: Skeptics and Google's own investors say these projects take too long and that they're too future-forward. How do you respond?

AT: I'm not even sure what that means, "too future-forward." That sounds like a compliment, not an insult. Our goal is not to produce immediate results. We've been tasked

that's different from saying we have to produce liquid value by today or it's all worthless. That's not the spirit of long-term bets.

PS: What are you most proud of?

AT: It's not any one project. It's the factory. Our goal is to make a moonshot factory, to systematize innovation in an efficient and productive way—and to kill things when we have to. The truth is that most companies end up littered with a huge number of un-killed projects because there isn't the culture in place, the belief structure in place that allows those projects to get ended quickly. Two days ago, we killed the largest project we've worked on here. It's been going for more than two years and had 20-some people working on it.

PS: What was it?

AT: I can't tell you. It was an unannounced project. And it's good that we didn't announce it, for exactly the reason I said [laughs]. *PS*

HOW ASTRO TELLER BECAME CAPTAIN OF MOONSHOTS

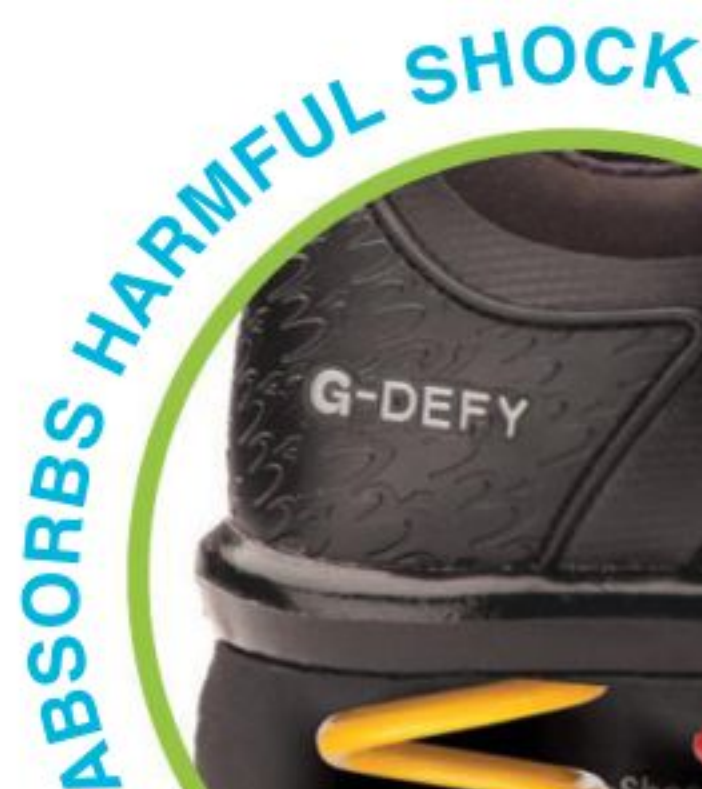




G-DEFY
GAMMA RAY

Scientifically
ENGINEERED
to **DEFY**
GRAVITY

VersoShock



U.S. PATENT #US8,555,526 B2



They are awesome, saved my job... I work on my feet all day and used to pack my knees with ice, now I come home with no pain.

— Ron B.



VersoShock Patented Technology In Every Step



Feel better. Do more.

The stress and discomfort of being active and on your feet can destroy your quality of life. As you age, cartilage and other tissues that protect your joints become thinner and less resilient. Gravity Defyer® footwear helps protect your body and provide shock absorption from the ground up. Jogging, running, walking – even routine standing, generate punishing impact. These forces produce lasting damage and wear on the body. Gravity Defyer footwear changes how our bodies

relate to the forces that prevent us from leading more active lives.

The Ultimate Shock Absorbing Footwear

With each step our patented shoe technology returns energy to you, to help you stay active and on your feet longer. A more active you means your muscles build strength and endurance, your body receives more oxygen and nutrients, and the heart and lungs work more efficiently. As your body gets more efficient you will have more energy to live the life you've always dreamed of!

Gamma Ray \$145

MEN • SIZES 7.5-15

MEDIUM & WIDE WIDTHS

- BLACK TB9016MBB **MED/WIDE**
- WHITE TB9016MWS **MED/WIDE**
- BLUE TB9016MUL **MEDIUM**



WOMEN • SIZES 5-11

MEDIUM & WIDE WIDTHS

- BLK/PURP TB9016FLP **MED/WIDE**
- GRAY/RED TB9016FRI **MED/WIDE**
- WHT/BLUE TB9016FWU **MEDIUM**



- ✓ Absorb harmful impact
- ✓ Stay comfortable & active
- ✓ Support & protect your body
- ✓ Stand & walk with greater ease

WIDE WIDTH
AVAILABLE

X-WIDE WIDTH
AVAILABLE

\$30 OFF
YOUR ORDER

PLUS

FREE SHIPPING ON
ORDERS OVER \$125
Free Exchanges • Easy Returns

COUPON CODE: MC9KGZ9

Call 1 (800) 429-0039

GravityDefyer.com/MC9KGZ9

Gravity Defyer Corp.
10643 Glenoaks Blvd
Pacoima, CA 91331

EDITED BY *Breanna Draxler*

Next



Corals in shallow water sometimes produce a fluorescent pigment that protects them from harmful solar rays, like a sunscreen. But when researchers from Israel and the U.K. found deepwater corals that produced a brilliant rainbow of hues, they were floored. “There might be something completely undiscovered in reefs that could be incredibly useful,” says Jörg Wiedenmann, an oceanographer at the University of Southampton. The corals’ pigments, he says, might help in the lab. For example, one can change from green to red when exposed to near-UV light—a capability that could help researchers track cancer growth or test the effects of potential drugs on cell cultures. **LEVI SHARPE**

2.4

Estimated dollars’ worth, in billions, of jobs, food, and tourism that corals provide to the U.S. and its territories

Dick Rutan

On the Future of Flying



The Wright brothers aren't the only siblings to push the limits of flight: In 1986, pilot Dick Rutan flew nonstop around the world, spending nine days in the air on a single tank of gas. He made the trip in a plane called *Voyager*, which his brother, Burt, designed. Today he's still at the forefront of aviation, busy building a new hyper-efficient engine and reimagining what aircraft might be.

"I had an abnormal fascination for aviation at the expense of more normal character development."

7.3

Billions of airline passengers in 2034, as projected by the International Air Transport Association (compared with 3.3 billion in 2014)



“

Burt and I were issued flight plans instead of birth certificates. When we flew *Voyager* nonstop around the world, we showed that you could build a light, strong plane out of carbon fiber that will last indefinitely. Now we're at the dawn of learning how to fly into space—in planes. Burt designed *SpaceShipOne*, which won the Ansari X Prize. Its successor, Virgin Galactic's *SpaceShipTwo*, is on track to send civilians into space.

Innovators like Richard Branson of Virgin Galactic and Elon Musk of SpaceX can get you and me to space. And they can do it more efficiently and reliably than the government. Yes, there are risks involved. They will have problems and challenges, just as people did when the development of airplanes ramped up in the 1920s. But my mom always told me that it's not a crime to fail; it's a crime not to try.

With a company called Engineered Propulsion Systems, I'm now trying to transform planes' fuel flexibility and efficiency into something worthy of this century instead of the previous one. Our liquid-cooled cycle compression engines can run on any kind of fuel, from bacon grease to diesel to traditional jet fuel—a change that will revolutionize general aviation. The engines run beautifully smooth, with 35 percent better efficiency, and they're incredibly quiet.

Disruptive noise is actually one thing that holds back commercial aviation. We have the ability to fly large planes faster than the speed of sound, but U.S. law restricts their flight, in part, because of the sonic booms they create. We can solve that problem by taking hypersonic travel out of the air altogether. My vision is that we build something along the lines of the hyperloop: a system of carbon-fiber vacuum tubes. Inside, capsules can accelerate to, say, 10 times the speed of sound. Because they slide through an airless vacuum, there's no sound—and no sonic booms. You could go silently from Los Angeles to Tokyo in half an hour. It's doable right now. It just takes some vision. **AS TOLD TO SARAH SCOLES**

Listed coverages are provided based on whether Comprehensive and Collision Coverages are purchased. Details of coverages or limits may vary by state. All coverages are subject to the terms, provisions, exclusions and conditions in the policy and any endorsements. State Farm Mutual Automobile Insurance Company • State Farm Indemnity Company • Bloomington, IL



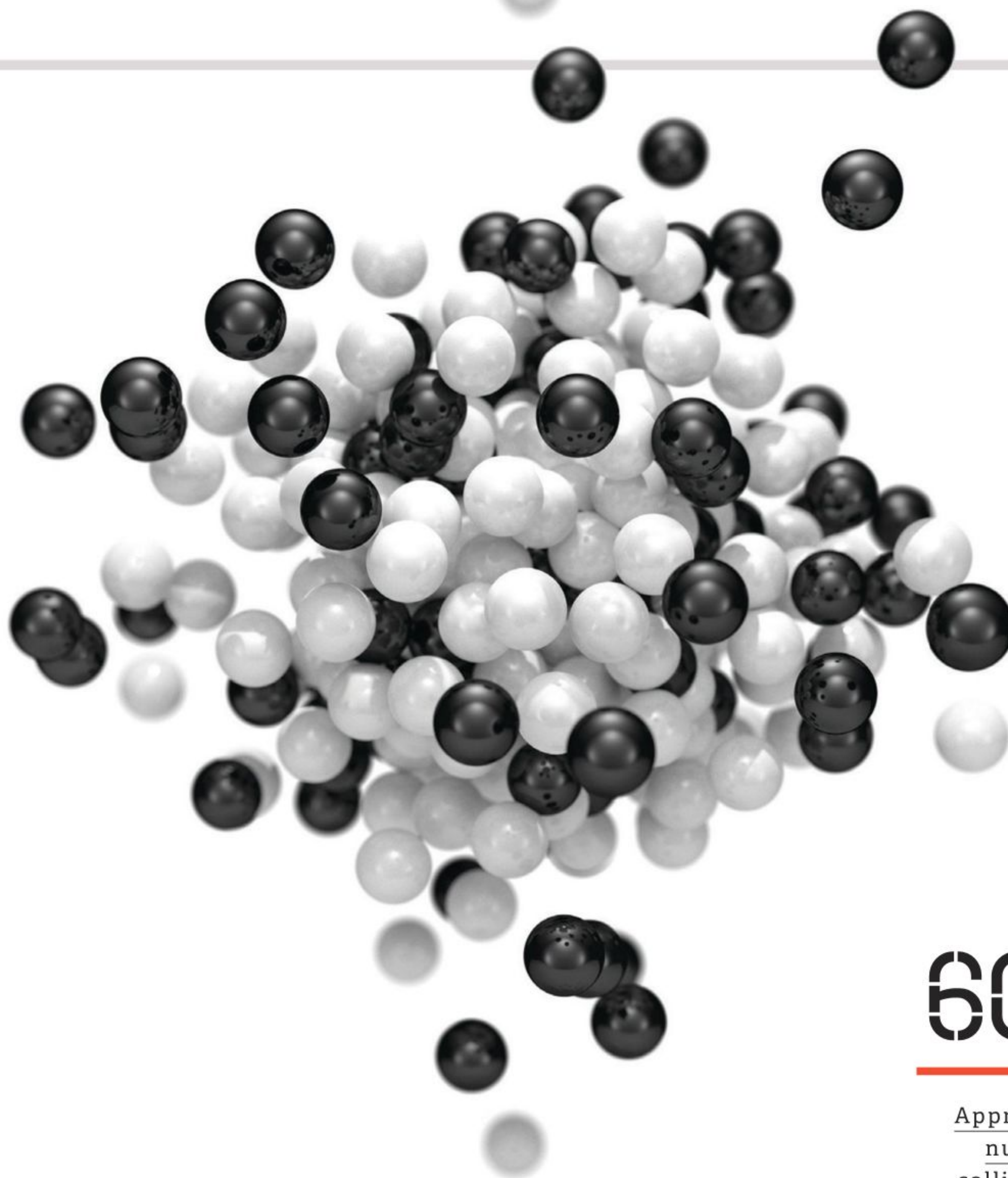
Choose coverage from the road captain. Our new, affordable rates include coverage that other companies charge as extras. Things like: help repairing or replacing your protective gear, costs incurred from being stranded, emergency roadside assistance, and the got-your-back service of a State Farm® agent.



Call us today at 844.242.2554 or visit st8.fm/motorcycle

The Search for Dark Matter

↓
It makes up a quarter of the universe. Without it, galaxies would fall apart, and stars would spin off into space. Dark matter is five times more abundant than normal matter (the stuff that makes up trees and stars and us), yet scientists can't see it nor figure out what it is. The one thing they can say for sure: They're getting closer to an answer. **ILIMA LOOMIS**



600

Approximate number of collisions, in millions, inside the Large Hadron Collider every second

→ **WIMPs**, or weakly interacting massive particles, got their name because they rarely run into normal matter. They've got to be big if they account for 27 percent of the universe. And they are suspected to be particles, but even that remains to be seen.

1

Astronomers in the 1930s realized that if they added up all the visible matter in a galaxy cluster, the combined gravity would not be enough to hold everything together. There had to be something else there—and there had to be a lot of it. Scientists initially referred to it as the missing mass but have since dubbed it “dark matter.”

2

The Large Hadron Collider—the world's most powerful particle accelerator—is expected to identify dark matter once and for all. The facility stands the best chance of discovering **WIMPs**, the leading candidate for the stuff. “It could prove all these speculative, far-off, dreamy theories a reality,” says particle physicist Jonathan Feng.

3

Colliders aren't the only game in town. A host of experiments seeks to understand dark matter by studying its side effects. Some aim to observe dark matter bumping into normal particles here on Earth. Others look for the reaction of two dark-matter particles colliding in space or underground.

“You can memorize the periodic table, but that's only 5 percent of the universe.”

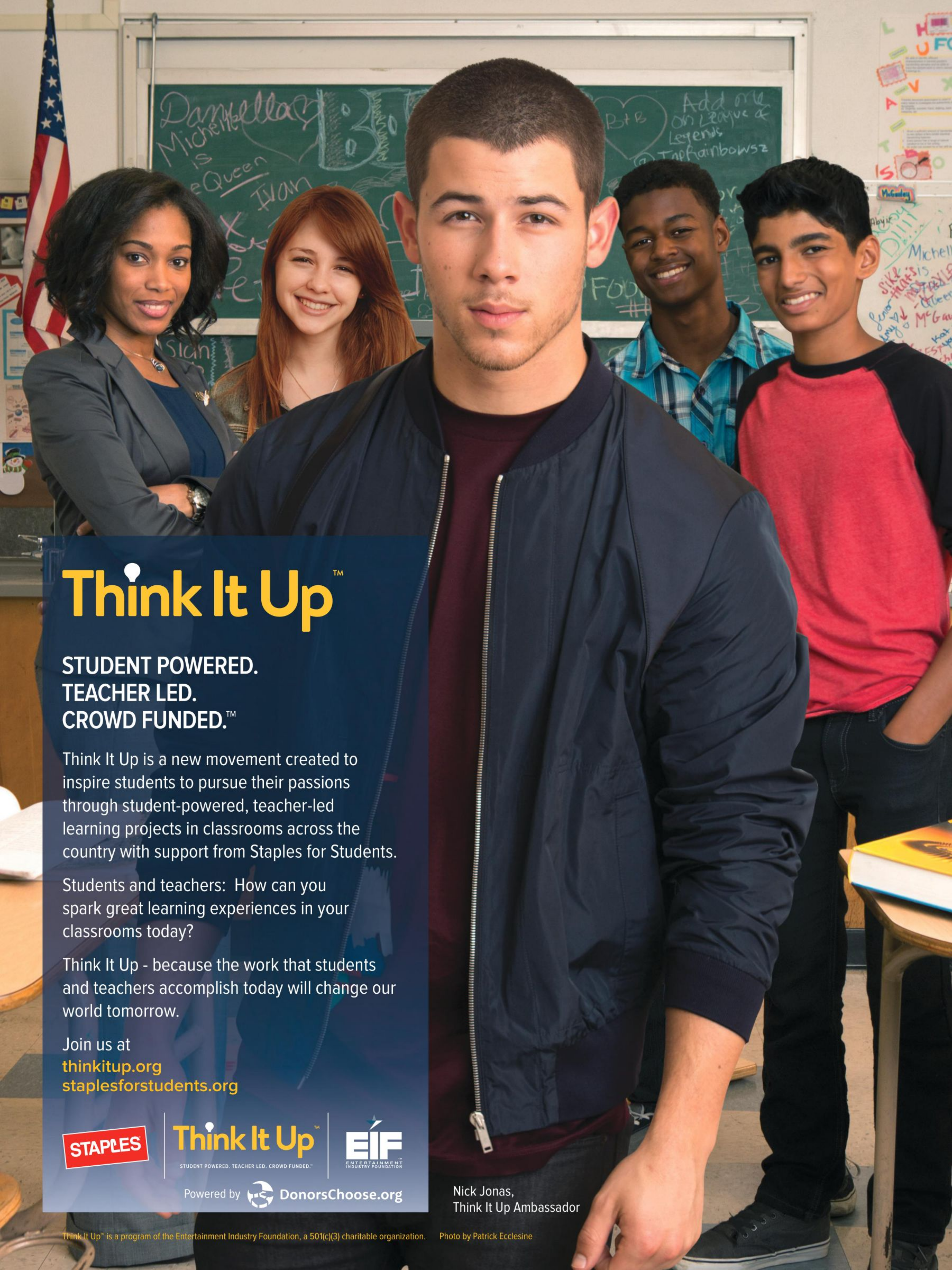
—JONATHAN FENG, PARTICLE PHYSICIST AT THE UNIVERSITY OF CALIFORNIA AT IRVINE

4

Scientists can also detect dark matter by observing how its gravity bends light that passes through it, like a cosmic prism. A team from the National Astronomical Observatory of Japan is surveying those warps and wobbles to create the first “dark-matter map,” which they aim to complete in 2019. It will reveal how dark matter is distributed—which gives clues to its mass and density.

5

Even if scientists identify dark matter, they'll be a long way from understanding how the universe works. The combined mass of dark and normal matter still leaves about 70 percent of the universe unaccounted for. What makes up the rest? Say hello to dark energy, a force so weird and mysterious that scientists will be puzzling over it long after the dark-matter case is closed.



Think It Up™

**STUDENT POWERED.
TEACHER LED.
CROWD FUNDED.™**

Think It Up is a new movement created to inspire students to pursue their passions through student-powered, teacher-led learning projects in classrooms across the country with support from Staples for Students.

Students and teachers: How can you spark great learning experiences in your classrooms today?

Think It Up - because the work that students and teachers accomplish today will change our world tomorrow.

Join us at
thinkitup.org
staplesforstudents.org



Think It Up™
STUDENT POWERED. TEACHER LED. CROWD FUNDED.™



Powered by  **DonorsChoose.org**

Nick Jonas,
Think It Up Ambassador



City dwellers are reportedly 40 percent more likely to develop mood disorders than people in rural areas. But walking for roughly 90 minutes in nature, according to a Stanford University study published in June, can calm the negative thoughts. The Essence Skyscraper is designed to provide urbanites with just such an experience. The 2,067-foot tower, envisioned by a Polish architectural team, won a 2015 skyscraper competition to redefine high-rises. Within the imagined 3.6 million square feet, visitors cross 11 distinct ecosystems from around the world. “We wanted something that would blend into an urban fabric,” says team member Jakub Pudo, “something that would allow us to go inside and get lost.” **CORINNE IOZZIO**

TOUR THE NATURAL WORLD IN A SINGLE TOWER

NATURAL LAYERS

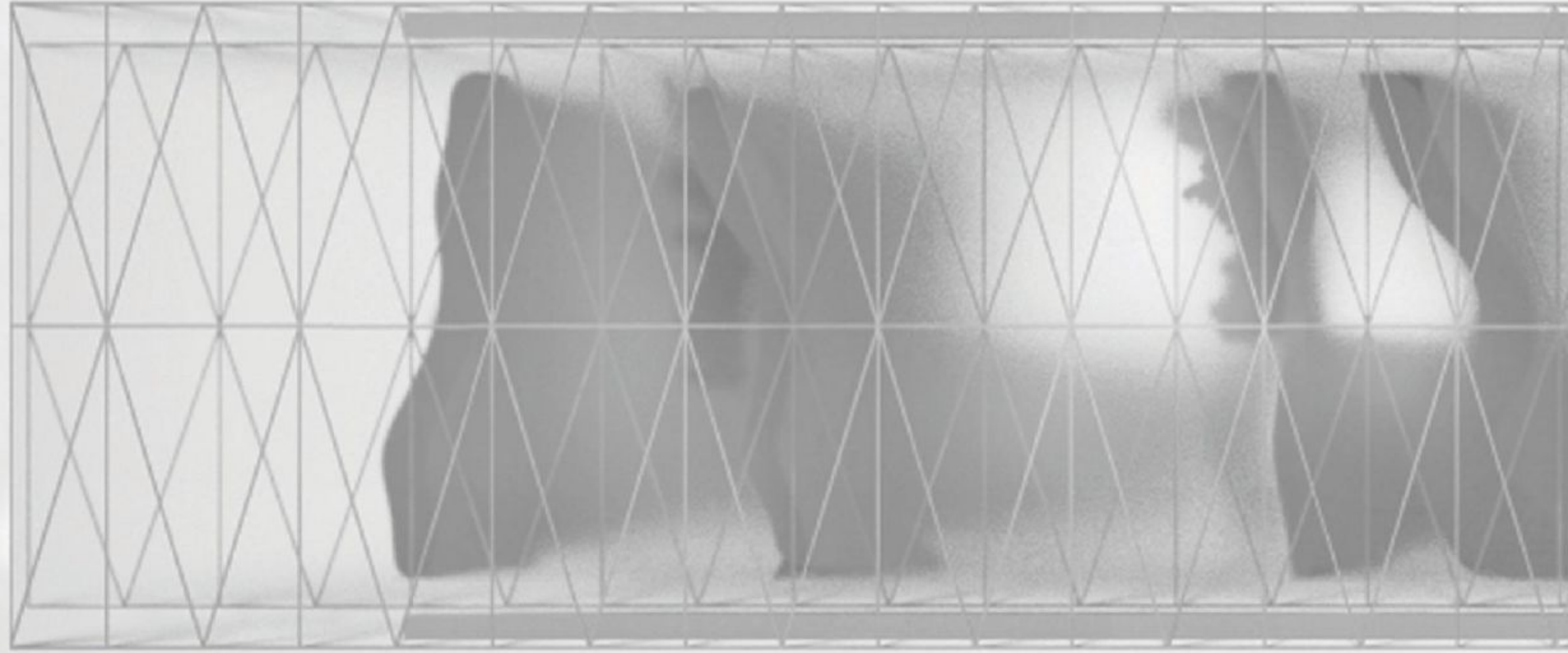
Visitors ascend through the ecosystems on a series of gradual ramps. The skyscraper’s design lacks the vertical beams and horizontal concrete slabs typically found inside a building, so these gradients also provide an element of structural support.

SYNCHED CLIMATES

Ecosystems flow gently into one another, thus avoiding the climate-control nightmare of, say, going from African savanna straight into an Antarctic glacier. Instead, similar climates, such as a jungle and a swamp, abut one another.

INNER WORKINGS

For visitors who want to quickly jump levels, staircases and elevators nest in a 33-foot gap between the building’s facade and the interior ecosystems. Utilities, such as HVAC and power systems, hide beneath the glacier, desert, and river levels.



LEVEL 11
GLACIER



LEVEL 9
GRASSLAND

ISOLATED VIEWS

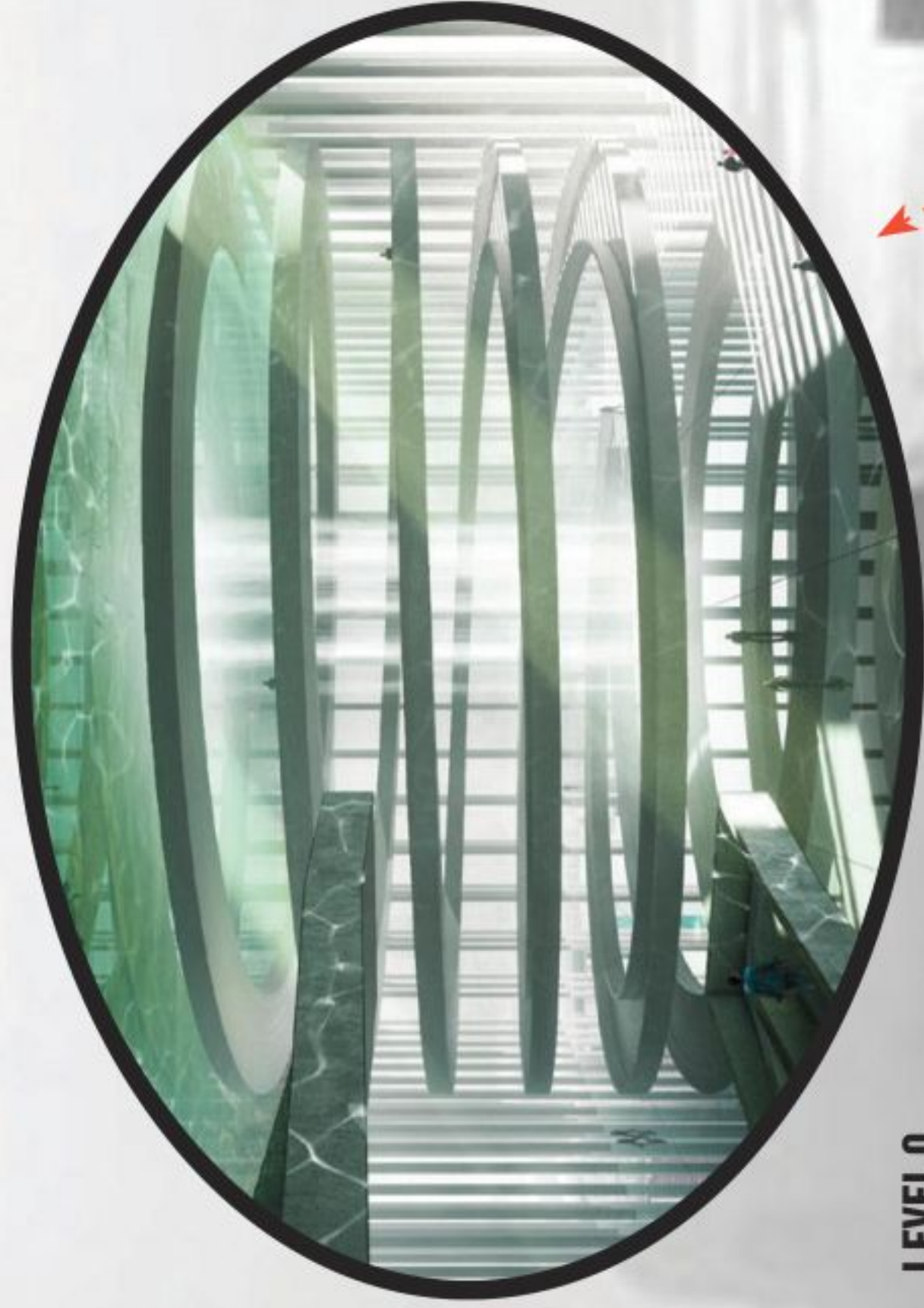
The all-glass building lets in sunlight, so there's no need for artificial lighting. But a synthetic coating gives the glass a foggy appearance, which obscures the urban jungle from the indoor one.

AMPLE HEADROOM

Ceilings range from 98 feet in the desert to 197 feet in the grassland to 295 feet in the mountain range (to accommodate its towering peaks). This open space makes the landscapes feel more natural, says Pudo.

H₂O CYCLE

Water moves through the tower from top to bottom. It melts off a glacier and flows into a river, which drops down over a waterfall and percolates into a swamp before making its way into the ocean below.



LEVEL 0
UNDERWATER

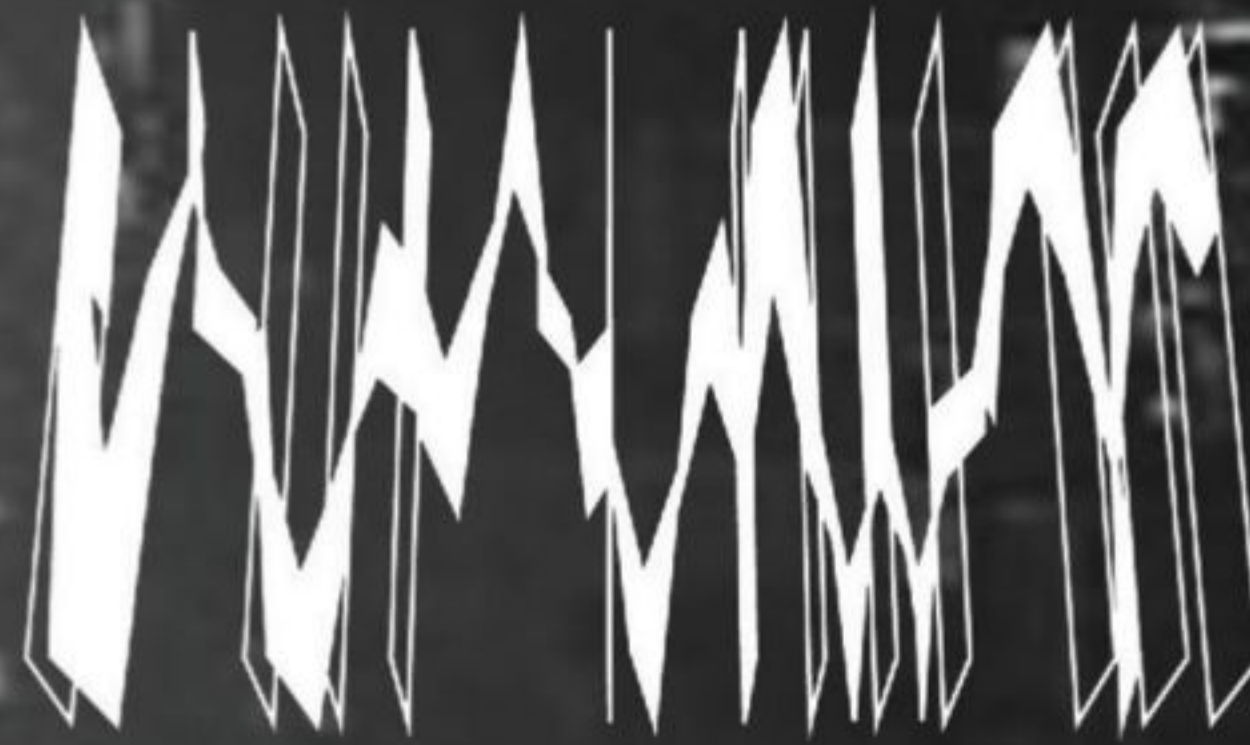
ONE-STOP GLOBAL ADVENTURE

Ferdinand Magellan's journey around the world took three years. Circumnavigating the globe in the Essence Skyscraper requires only an afternoon.



Level Up

- 11 Glacier
- 10 Mountain
- 09 Grassland
- 08 River
- 07 Waterfall
- 06 Cave
- 05 Desert
- 04 Savanna
- 03 Swamp
- 02 Jungle
- 01 Ocean
- 00 Underwater



Time Machine

Guns Get Smarter

As any science-fiction fan knows, a smart gun is designed to work only for the person authorized to use it. Since the 19th century, Smith & Wesson, Colt, and even Silicon Valley have all attempted to disrupt the now-multibillion dollar gun industry and bring a theft-proof firearm to market. While politics and public opinion have hampered previous efforts, a new generation of smart guns is now on the cusp of becoming reality. **MATT GILES**

1886: S&W introduces a gun that requires pulling the trigger and a lever simultaneously. Bonus: It's childproof. More than 500,000 are sold over its 50-plus-year run.

1974: Magna-Trigger launches. A magnet prevents the gun from firing unless a compatible magnetic ring is worn.

1977: Sci-fi comics embrace the idea. Judge Dredd's pistol, the Law-giver, scans palm prints and self-destructs in anyone else's hand.

1994: Congress funds Sandia National Labs to study if smart guns can help lower the rate (11 per year) of police killed with their own weapon during a struggle.

1998: Colt unveils the Z40, a radio-frequency prototype with a matching wristband. Second-amendment groups fear stricter gun laws and boycott the company, whose CEO resigns.

2001: Firearm-maker iGun produces a shotgun with an RFID-like magnetic tag. The market yawns, so the idea stalls.

2008: After working for nearly a decade on a multisensor biometric for a smart gun, the New Jersey Institute of Technology wins a \$250,000 grant to develop it.



"My gun has to be perfect or it could kill the smart-gun market forever."

—KAI KLOEPFER, FOUNDER OF ÆGEN TECHNOLOGIES

2012: James Bond uses a smart gun that recognizes his palm print in *Skyfall*. "Only you can fire it," Q tells him.

2014: German company Armatix releases the first smart gun commercially available in the United States: the iP1. This .22-caliber pistol pairs wirelessly with a watch. Gun shops initially agree to sell the iP1 but back out due to intense consumer pressure.

Meanwhile, the Smart Tech Challenges Foundation awards \$1 million to develop smart-gun technology. Teenager Kai Kloepper wins a portion of that for his fingerprint-activated pistol design, and starts company Ægen Technologies to commercialize it—all before he turns 18.

2015: Seattle holds the first-ever smart-gun symposium. Shortly after, a bill is introduced to Congress that would allocate grants to further smart gun research. "Once we have funding, it'll take just two years to get to market," says Donald Sebastian, senior vice president of R&D at NJIT.

2018-ish: Four smart guns aim to enter the market, including NJIT's and Kloepper's. "With the first generation of smart guns, people were hesitant about new technology," Kloepper says. "As our lives have become more integrated, everyone is racing to develop smart guns as quickly as possible."

FYI

DATING APPS GO VIRAL

Thanks to the growing popularity of apps like Tinder, one in five relationships now begins online. But users might find more than romance when they swipe right. In 2014, sexually transmitted disease rates in Rhode Island reached a 10-year



high. Cases of gonorrhea alone rose 30 percent (in the state's relatively small population), mirroring a national trend in STDs. Geospatial apps like Tinder and Grindr could be one reason: A 2014 study found that gay men who used them had higher rates of gonorrhea and chlamydia. But keep in mind, that's only a correlation. The usual suspects—drugs, alcohol, and multiple partners—are still at play, say state health officials. The apps likely enable risky behavior, not cause it. Swipe safely, folks.

REBECCA HARRINGTON



S.R.P
\$749

NOW
ONLY

\$99 + S&P

87% OFF - (Saving you \$650)



**LAZER
BLUE**

By Daniel Steiger

"THE NEXT GENERATION OF HYBRID" ...AND UNDER \$100

Timepieces International brings you the incredible **Daniel Steiger Lazer Blue Watch**.

In our opinion, the best looking hybrid watch on sale! What's so incredible about the Daniel Steiger Lazer Blue? As well as having an ultra modern look and style, this amazing watch is packed full of features and functions and is available in 18k Yellow Gold fused two-tone or classic steel colored version. This fantastic watch features a metal case structure, digital format windows showing 24hr, days of the week, seconds with an easily accessible alarm system. This incredible watch is robust enough for those always on the move, and yet made with comfort in mind with a modern sporty look. But perhaps the most stunningly cool feature of this astonishing timepiece is its lense. The Lazer Blue Crystal gives this magnificent watch a truly unique look. Integrated into the crystal itself the Blue Lazer coloring takes the look of this watch to another level. The level of **AWESOME!** What else is awesome about this fantastic watch? Quite simply its price. At an incredible **\$99** (plus shipping and handling). This is a unique buying opportunity not to be missed! **Limited stock available.**



Available in
Steel & Gold
Color Versions

CALL OUR CREDIT CARD HOTLINE NOW, TOLL FREE 24/7 ON 1-877 550 9876

And Quote Promo Code:

30 DAY MONEY-BACK GUARANTEE

PS59LZ

LIMITED STOCK AVAILABLE

OR order online at www.timepiecesusa.com/ps59 And Enter Promo Code **PS59LZ**

Timepieces International Inc, 12800 N.W. South River Drive, Medley, FL 33178

Decoded

AN APPETITE FOR DESTRUCTION

We're entering a sixth extinction, and the world's most invasive species is to blame: humans



This summer the Internet seemed to wake up to the fact that we're in the midst of a mass extinction. These things happen periodically. The Permian extinction 252 million years ago wiped out 95 percent of life on Earth, while the Cretaceous (65 million years ago) did in the dinosaurs. But this sixth one is different. Whereas powerful natural forces—volcanic eruptions, asteroid impacts, and atmospheric warming—were behind all five previous mass extinctions, this one is caused by us.

The indictment came in June, when a team led by Gerardo Ceballos of the Universidad Nacional Autónoma de México published a paper on extinction rates in the fossil record. They found that historically, two vertebrate species out of 10,000 went extinct every 100 years. When they added humans to the equation, the rate increased a hundredfold. In the past century, they calculated, nine species should have disappeared. Instead, 477 did.

The ostensible causes are all too familiar. We clear-cut forests, which leads to erosion and habitat loss. We overfish, causing marine ecosystems to collapse. We crank out billions of tons of greenhouse gases, which accelerates climate change. But there's an even more profound problem at work: Humans are hardwired for destruction.

Like all species, we have a strong instinct to survive, but unlike most, we serve that instinct through intellect. Our ability to problem-solve is unparalleled. In 200,000 years, we've spread to every continent, tripled our life spans, and adapted to extreme environments.

Our runaway success has come



“Ever since we migrated out of Africa, we have been transforming landscapes and causing extinctions.”

—MARK LOMOLINO, ECOLOGIST AT THE STATE UNIVERSITY OF NEW YORK

with profound and unexpected costs to the finite and interdependent system that is Earth. It's a frightening fact that “we, as one species, could have an impact rivaling that of a massive asteroid crashing into the Caribbean Sea,” says Mark Lomolino, an ecologist at the State University of New York.

A not-insignificant side effect of survival instinct is consuming today rather than saving for tomorrow. “We evolved to understand and act

8.7

Estimated number of species on Earth, in millions, according to a 2011 study; we've discovered only 25 percent

on the short term,” says Paul Ehrlich, an ecologist at Stanford University involved in the June study. “Until very recently, we had no capability of acting in the long term.” Now, though, our technology allows us to model the future and plan ahead. “The principal causes of extinction are anthropogenic—therefore, things we can address and control,” Lomolino says. If human ingenuity has got us into this mess, then it can get us out. **GRENNAN MILLIKEN** *PS*

Chicago Doctor Invents *Affordable* Hearing Aid Outperforms Many Higher Priced Hearing Aids

Reported by J. Page

CHICAGO: A local board-certified Ear, Nose, and Throat (ENT) physician, Dr. S. Cherukuri, has just shaken up the hearing aid industry with the invention of a medical-grade, affordable hearing aid. **This revolutionary hearing aid is designed to help millions of people with hearing loss who cannot afford—or do not wish to pay—the much higher cost of traditional hearing aids.**

**"Perhaps the best quality-to-price ratio in the hearing aid industry" — Dr. Babu, M.D.
Board-Certified ENT Physician**

Dr. Cherukuri knew that untreated hearing loss could lead to depression, social isolation, anxiety, and symptoms consistent with Alzheimer's dementia. **He could not understand why the cost for hearing aids was so high when the prices on so many consumer electronics like TVs, DVD players, cell phones, and digital cameras had fallen.**

Since Medicare and most private insurance do not cover the costs of hearing aids, which traditionally run between \$2,000-\$6,000 for a pair, many of the doctor's patients could not afford the expense. Dr. Cherukuri's goal was to find a reasonable solution that would help with the most common types of hearing loss at an affordable price, not unlike the **"one-size-fits-most" reading glasses** available at drug stores.

He evaluated numerous hearing devices and sound amplifiers, including those seen on television. Without fail, almost all of these were found to amplify bass/low frequencies (below 1000 Hz) and not useful in amplifying the frequencies related to the human voice.

Inspiration From a Surprising Source

The doctor's inspiration to defeat the powers-that-be that kept inexpensive hearing aids out of the hands of the public actually came from a new cell phone he had just purchased. **"I felt that if someone could devise an**

- **Designed by a Board-Certified Ear, Nose, and Throat (ENT) Doctor**
- **Doctor-Recommended, Audiologist-Tested**
- **★★★★★ Top rated hearing aid online—thousands of satisfied customers**
- **Batteries Included! Comes Ready To Use**
- **FDA-Registered**
- **Save Up To 90%**
- **Free Shipping Available**
- **100% Money-Back Guarantee**



affordable device like an iPhone® for about \$200 that could do all sorts of things, I could create a hearing aid at a similar price."

Affordable Hearing Aid With Superb Performance

The high cost of hearing aids is a result of layers of middlemen and expensive unnecessary features. Dr. Cherukuri concluded that it would be possible to develop a medical-grade hearing aid without sacrificing the quality of components. The result is the **MDHearingAid PRO**, well under \$200 each when buying a pair. **It has been declared to be the best low-cost hearing aid that amplifies the range of sounds associated with the human voice without overly amplifying background noise.**

Tested By Leading Doctors and Audiologists

The **MDHearingAid PRO** has been rigorously tested by leading ENT physicians and audiologists who have unanimously agreed that the **sound quality and output in many cases exceeds more expensive hearing aids.**

MDHearingAid® >>> PRO



Proudly Assembled in the USA
from Domestic & Imported Components.



**45-DAY
RISK-FREE
TRIAL**



Doctors and patients agree:

**"BEST QUALITY SOUND"
"LOWEST AFFORDABLE PRICE"**

*"I have been wearing hearing aids for over 25 years and these are the best behind-the-ear aids I have tried. **Their sound quality rivals that of my \$3,000 custom pair of Phonak Xtra digital ITE.**"*

—Gerald Levy

*"I have a \$2,000 Resound Live hearing aid in my left ear and the **MDHearingAid PRO** in the right ear. **I am not able to notice a significant difference in sound quality between the two hearing aids.**"*

—Dr. May, ENT Physician

*"They work so great, my mother says she hasn't heard this well in years, even with her \$2,000 digital! **It was so great to see the joy on her face. She is 90 years young again.**"*

—Al Peterson

**For the Lowest Price
Call Today**

1-800-873-0680

**Phone Lines Open 24 Hours
EVERY DAY**

www.MDHearingAid.com

**Use Offer Code CE54 to get
FREE Batteries for a Full Year!**

FREE Shipping Available

©2015



The Future of Food

Traditional farming is outdated and broken. Thankfully, a raft of new technologies can efficiently feed the growing global population—if we adopt them quickly enough.

Farms Grow Up

BY KEVIN GRAY

This past winter, as near-record snows piled up outside his 30,000-square-foot warehouse off Lake Michigan, Robert Colangelo stood inside, bathed in blue and red LEDs, and surrounded by crops of butter lettuce and herbs.

Located 40 miles outside Chicago, this is Green Sense Farms, the largest indoor vertical farm in the U.S. The CEO of Green Sense, Colangelo grows produce—including micro-greens and basil—hydroponically, feeding them a constant stream of nutrient-rich water, in racks 25 feet high, beneath specialized LEDs, monitored by computer, and harvested as often as twice a week. “We can grow a large volume, in a small footprint, 365 days a year,” says Colangelo. “We’re not subject to rain or drought. We control the environment. So the weather is perfect every single day.”

Indoor vertical farming has become a major player in the niche market of locally grown, high margin, perishable greens—such as kale, watercress, and lettuces. It eliminates the need for pesticides. It reduces the spoilage that occurs from trucking perishable produce 3,000 miles across the continent. It significantly cuts the carbon footprint of farm tractors and refrigerated trucks. And it meets the growing demand for fresh produce among middle-class urban dwellers.

Many say it could help avert a looming global food crisis and one day become the future of agriculture. The United Nations predicts that the global population will swell by 2.4 billion people by the middle of this century, and 66 percent of the planet will live in cities. That presents a challenge to feeding everyone. With an increasing demand on the world’s arable land, and droughts and floods predicted to more frequently devastate crops—driving food prices higher—one solution is to grow food, in cities, where it’s needed.

Technologists and green-thinking entrepreneurs have already spent hundreds of millions of dollars raising indoor vertical crops across the globe. In eastern Japan, in a former Sony semiconductor factory,



Green Sense Farms near Chicago blasts its plants with high-intensity LEDs for up to 22 hours at a time.

one plant scientist harvests 10,000 heads of lettuce a day. In New Jersey, a former Cornell University agriculture professor, with backing from Goldman Sachs and others, is helping to turn a run-down steel factory into a 69,000-square-foot farm. It will be capable of turning out 2 million pounds of produce annually, eclipsing Colangelo’s farm when it opens this winter. The new farm will use 95 percent less water than a field farm, and like others offer more productivity per square acre, and save energy costs such as tractor fuel.

At Green Sense, Colangelo partnered with electronics giant Philips, which created a unique spectrum of blue and red light—the optimal light for photosynthesis in leafy greens—in the 9,000 LEDs he uses. When plants sit directly beneath such specially tuned LEDs, they don’t spend energy growing upward. They grow outward in dense leaves, which optimizes nutrient density and means less growing time. “We can turn a micro-green crop roughly every 12 days, baby greens about every 30 days, and lettuces about every 35 days,” Colangelo says. Field farmers get one or two chances a season to turn crops.

Colangelo sells his Green Sense branded produce to Whole Foods Market, which stocks it in 48 stores in eight states. “The stores get it fresh, and for the customer, it’s better quality,” Colangelo says.

He is also looking into new ways to improve his operation. He recently partnered with a genomic sequencing lab in Shenzhen, China, to identify seeds that best respond to LED lights. “You can create hybrid seeds, and then you can naturally crossbreed them with other plants so they double your crop yield,” he says. “They’ll be like non-GMO superseeds.”



Engineers can fine-tune LEDs to match each plant's needs, speeding up growth cycles.



The Wikipedia of Farming

How MIT's Media Lab is rewiring the way plants are grown

BY KEVIN GRAY

Two years ago, then MIT graduate student Caleb Harper built a fully networked farm of tomatoes, lettuce, and broccoli inside a fourth-floor lounge at the school's famed Media Lab. He hoped to prove he could use data science to optimize crop yields, boost nutrient density, and trim water consumption by 98 percent compared with traditional

dirt farming, all of which he did. But there was no meaningful way to share his data with the world. Despite an ongoing boom in agricultural technology, no one cared about his findings or dared to share theirs. This September, he launched the Open Agriculture Initiative, the first open-source platform for global agriculture and food hackers.

Popular Science: How is agriculture not open-source? Don't we pretty much know how to grow a tomato?

Caleb Harper: No. Traditional agriculture is closed and opaque. It's understood by very few people at a production scale. How do I find nutritional-uptake studies on lettuce? Where can I get data on crop yields in Ghana? We want people to research this stuff, share it online, and grow healthier food and more of it around the world. There's a huge appetite for this.

PS: So who is hoarding all the useful information?

CH: Right now, there are 20,000-foot indoor farms popping up all over the world. But no one shares anything because they think their IP is so valuable. One place called PlantLab in the Netherlands has a warehouse full of little pods where they create microclimates, which in turn create a novel flavor, a novel shape, and specific nutrients in the plants. And then they patent their processes. To be fair to them, they're doing awesome work. This stuff can take a lifetime to figure out. But they are creating all this knowledge and then scooping it under a black box. We want to create plant-growing recipes that look like Wikipedia.

PS: How do you propose to do that?

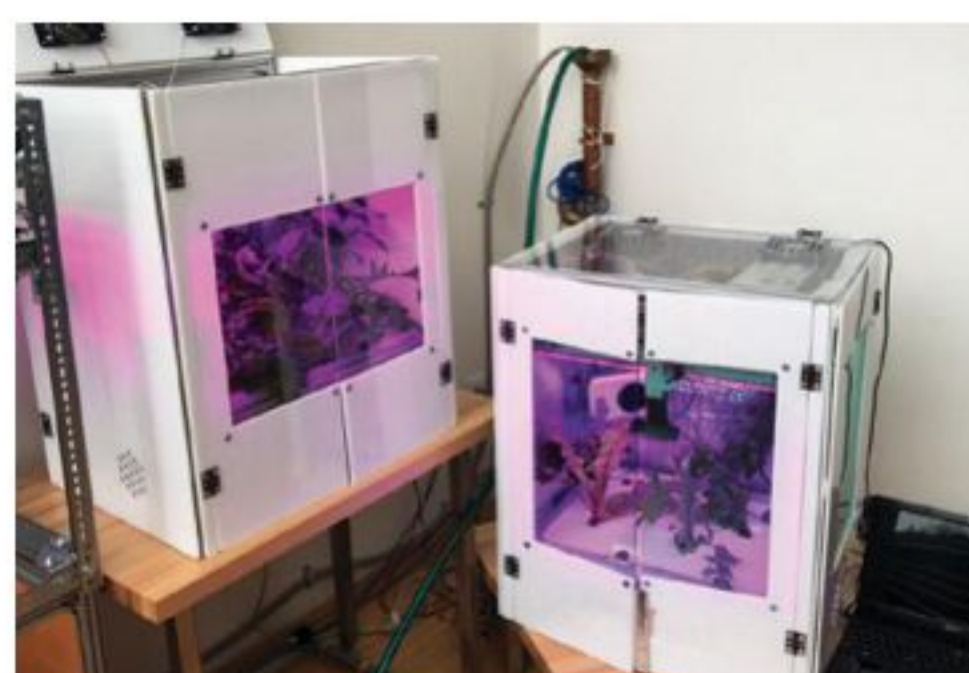
CH: One thing we're developing is a shipping-container farm modified with networked sensors and growing environments. It can be used by other research institutions and by corporate cafeterias. So we'll all be connected to each other's data. Another cool thing is the Personal Food Computer. We released it for testing in September. It's a 2-by-2-foot cube with microprocessors, an LED light bar, and an irrigation system. We can change the temperature, the CO₂ level, the amount of nutrients in the water, the water temperature, mineral fertilizer—all this stuff.

PS: It sounds like the state of 3-D printing 10 years ago, when the open-source RepRap helped create a huge community of printer hackers.

CH: Exactly. Our Personal Food Computer is an open-source bio bot, a food bot for maker enthusiasts to create a community. What's been holding agtech back is that none of the black boxes and systems can talk to each other.

PS: So what can you do with it?

CH: People always want me to answer that. I dunno. It's like personal computers in the '70s. The extensions are endless. You can be an idiot and have fun, or revolutionize how tomatoes are grown. It could become a personal pharmacy. We can all be sequenced, and grow the food best for us. That's one of a thousand stories waiting to be written.



The Personal Food Computer is the first open-source food bot.

Food Without Food

BY RACHEL FOBAR

Our attachment to food is antiquated. So the argument goes: It takes time and energy to buy and prepare, and it can lack nutrition (we tend to cook away the good stuff). We can now drink our meals. Meal-replacement shakes—different from protein drinks that serve as supplements—optimize nutrient efficiency, save money, and turn the messy business of eating with others into a hobby.

SOYLENT

Ever since Soylent launched as a powder in 2013, it's been a trend among Silicon Valley coders. Now it comes in even more convenient 14-ounce drink bottles. Each bottle holds 400 calories (you need six or seven to maintain a minimum daily calorie requirement for an active adult). The new release includes soy for its primary protein source and algae—in the form of algal oil—for half of its fat content. Texture: cow's milk.

AMBRONITE

Thought of as an organic alternative to Soylent, Ambronite is made from a list of easy-to-recognize, easy-to-pronounce ingredients, including oats, rice bran, and flaxseed. You can probably live off it, but it is pitched as a "productivity tool" for creative types stuck in lunch meetings or grinding through weekend hackathons. Each bag of powder contains a 500-calorie serving with 30 grams of protein, 13 different vitamins, and fiber.

DIY.SOYLENT

Soylent is not patented, so thousands of diet hackers have decided to make their own versions, posting them on diy.soylent.com. Rather than a one-drink-fits-all approach, the site offers customized meal-replacement recipes based on age, sex, weight, and daily activity level, and whether you want to reduce or maintain weight. For example, "Bachelor Chow" delivers 2,000 calories per day and is made with only 10 ingredients.

The Future of Food

The iPhone-Driven Farm

Cheap, networked technology is transforming our crops.

TAYLOR DOBBS

Since Dorn Cox began automating his 250-acre New Hampshire farm four years ago, he has installed dozens of sensors. Some measure moisture in soil around his squash. Some track temperatures in the greenhouse air around his cucumbers. Others track wind speed and rainfall in segments of field roughly a quarter-acre in size. When something is amiss—temperatures are too high or the soil is too dry—he receives an alert on his smartphone. He also sends out drones to survey his field crops for dryness, soil erosion, and plant health.

"On a farm, there's a lot going on," Cox says. "Being able to keep track of it all without having to hire more people is important. It lets you do a better, more efficient job."

For centuries, farming was an intuitive process. Today, it's networked, analytical, and data-driven. Large farms (1,000 acres or more) started the trend, adopting the tools of precision agriculture—using GPS-guided tractors, drones, and computer modeling to customize how each inch of land is farmed. Farm managers can measure and map things like soil acidity and nitrogen levels, and then apply fertilizer to specific plants—not just spray and pray. As a result, they get the most out of every seed they plant. Such methods have reduced farm costs by an average of 15 percent and increased yields by 13 percent, according to a 2014 survey by the American Farm Bureau Federation.

Small farms—which make up 88 percent of all farms in the U.S., according to the Department of Agriculture—are now adopting similar methods, powered by a proliferation of affordable sensors, drones, cameras, wireless networks, and data plans. And they sometimes see better results than

large farms. Cox, for one, says he has cut labor and fertilizer costs by as much as 70 percent, and in some cases doubled his crop yields. He and his fellow farmers also share data through farmhack.org. In the past, innovation came from individual experiments. Now, "if you're able to capture new data with the help of other farms," Cox says, "all those experiments add up to much faster learning."

At Cox's Tuckaway Farm, about 20 miles northeast of Portsmouth, Cox uses farmOS, an open-source farm-management software he helped develop. He can also create 3-D models of crops to show biomass volume. He can look at

larger landscape patterns via drone. And he can share information in real time. His next innovation will be employing robots in the field. When corn grows to a mature height, it's difficult to get through the rows to apply nitrogen. Instead, farmers apply it to the soil at the start of a season and hope it lasts. But Rowbot—created by Minnesota agricultural engineer Kent Cavender-Bares and his two brothers, one a roboticist—is small and sturdy

Farming was once intuitive. Today, it's analytical and data-driven.

enough to carry several gallons of nitrogen and work its way down the space between rows, applying nitrogen when needed.

"In the future, the machines will be out there doing work and at the same time learning about that field," says Cavender-Bares. That data will, in turn, affect how farmers like Cox manage their land. "We have the pieces to put this together," Cox says. "We haven't had that before. That's a big deal."



Designer Produce

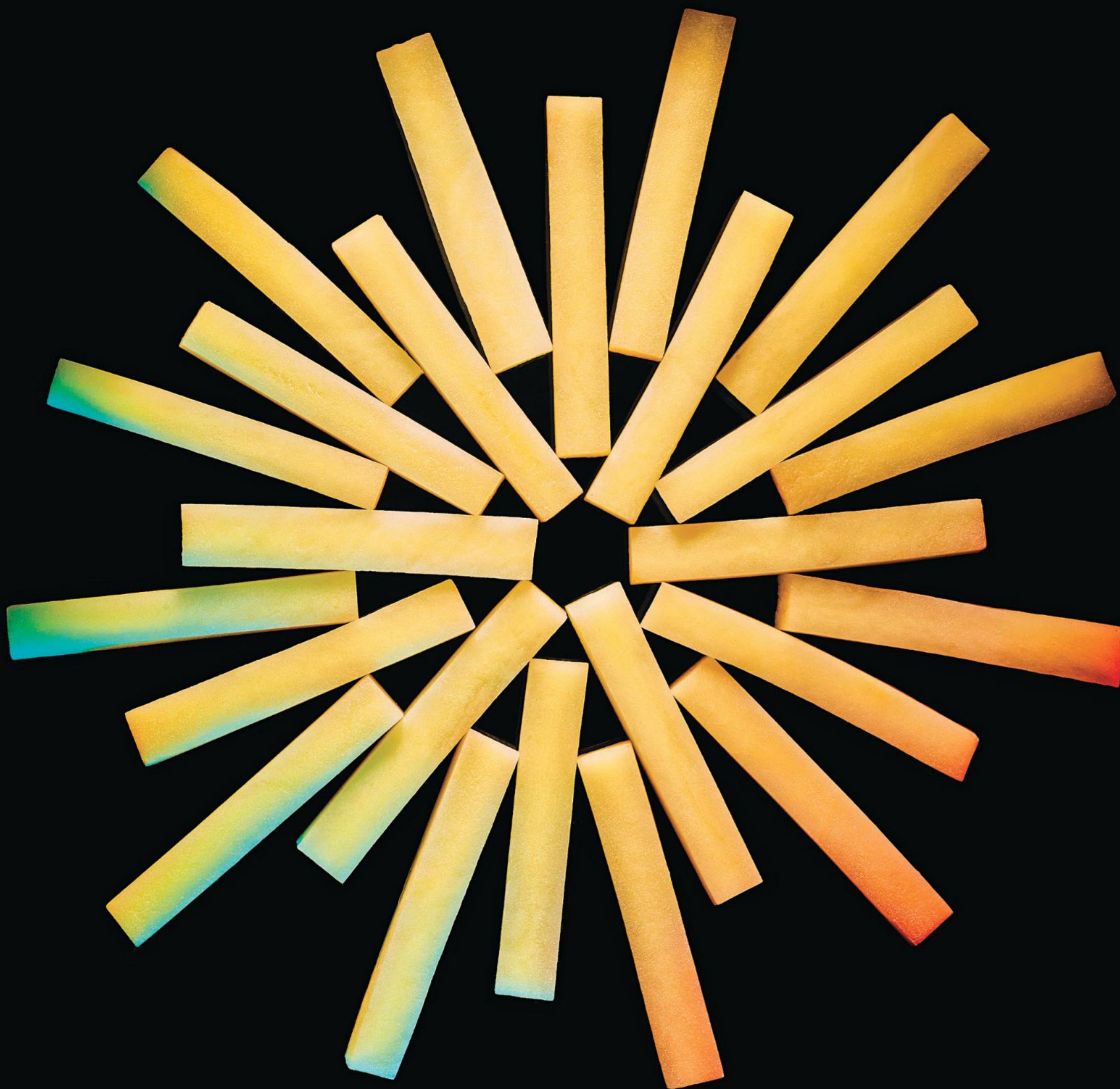
BY BROOKE BOREL

Each year, groceries, restaurants, and hotel chains collectively toss out some 400 million pounds of fresh potatoes due to bruising and black spots. (Consumers loathe a bruised spud.) Boise, Idaho, food giant Simplot—one of the largest privately held food producers in the nation—has now genetically modified potatoes so we'll waste less. Its new Innate line of Russet Burbank (a standard for French fries), Atlantic (a chip staple), and Ranger Russet (an all-purpose potato) is bred to have less bruising. Compared with typical potatoes, Innates also have up to 70 percent less acrylamide—a potentially cancer-causing chemical formed when potatoes are cooked above 248 degrees, such as when frying French fries or baking chips. In other words, they're healthier. The new potatoes are among the latest GMOs with direct consumer benefits, joining the nonbrowning Arctic apple, and Pioneer's Plenish soybean oil, which contains the healthy fat omega-9.

Simplot—an 86-year-old company that invented the frozen French fry and dehydrated potato—spent more than 14 years devising the Innate varieties. To create them, engineers extracted genes from cultivated and wild potatoes, and inserted them into the DNA of its target varieties. In a process that scientists call "gene silencing," the new genes switch off the host genes that lead to bruising and acrylamide production.

This summer, Simplot's new potato line began landing in produce aisles, on restaurant plates, and on room-service trays in hotels. (In 2012, consumers ate 52 pounds of potatoes per person.) But some big potato buyers, like McDonald's, aren't buying, likely because they fear consumers' reaction. Although 88 percent of scientists say GMOs are safe to eat, only 37 percent of the public agrees, according to a 2015 Pew Research Center survey.

Still, it's unlikely consumers will notice or appreciate the new spuds. "I'm not convinced that the fact that it's low acrylamide will be looked upon by consumers as a big benefit," says Greg Jaffe, the biotechnology director at the Center for Science in the Public Interest, "because I don't think most consumers are aware of acrylamide and the issues around it."



This summer, food giant Simplot released genetically modified potatoes, designed to reduce bruising, the latest GMO on the market.



RDM Aquaculture in Indiana grows these Pacific white shrimp in closed-system pools, without the need for costly antibiotics.

The Midwest Is Our New Ocean

The most sustainable way to raise seafood might be on land.

BY LOIS PARSHLEY

Americans eat about 4 billion pounds of seafood a year, but many of us don't know where our fish or shellfish come from—or even what we're eating. (Seafood is sometimes intentionally mislabeled.) Karlanea Brown's family-run shrimp farm, in landlocked Indiana, offers a cheaper, sustainable, and more transparent approach.

For years, the Brown family had raised hogs but became frustrated by plummeting prices in the market. So they began looking into aquaculture. In 2010, they decided to raise shrimp. Their farm, RDM Aquaculture, is now the largest such operation in Indiana—which is a U.S. leader in inland shrimp farming—and produces 250,000 shrimp a month.

Today, much of the world's shrimp is grown in small farms in Southeast Asia that don't always measure up to U.S. health-safety regulations. In 2011, the Government Accountability Office cited several examples of imported samples tainted with unregulated antibiotics. Farms like Brown's provide a safe and healthier alternative.

Brown raises her Pacific white shrimp indoors in large recirculating plastic tanks that rely on bacteria to consume waste. The closed-loop system is surprisingly low-tech: The tanks are essentially swimming pools with air pumped in to keep the bacteria in suspension—a system based on Texas A&M research, and refined by Brown and her family. The tanks don't require filters to keep the water clean, and that clean water removes the need for costly antibiotics. Brown's farm

is now one of 11 in the state, up from three when she started in 2010. "Indiana could become the shrimp capital of the world," Brown says.

That might not be as far-fetched as it sounds. In a 2011 report, the United Nations' Food and Agriculture Organization found that around 90 percent of the world's fisheries are fully exploited or overexploited. To take pressure off ocean stocks, the world must produce an additional 40 million metric tons of farmed seafood over the next 15 years, according to Michael Rubino, director of the National Oceanic and Atmospheric Administration fisheries aquaculture program. Aquaculture is

already the fastest-growing food-producing sector in the country. There is one drawback to Brown's approach: Even recirculating systems often feed their stock other seafood that has been harvested from the ocean by dredging or by other potentially damaging

"The ocean is dying every day unless we change things. By moving inland, we have a chance to keep seafood going."

methods. Scientists have developed an alternative, vegetarian-based feed for carnivorous fish, and this might eventually help.

As for Brown, she is already looking to branch out to raising crawfish, oysters, and talapia. "We have to keep growing," Brown says. "The ocean is dying every day unless we change things. By moving inland, we have a chance to keep seafood going." *Ps*



Push-Button Dinner

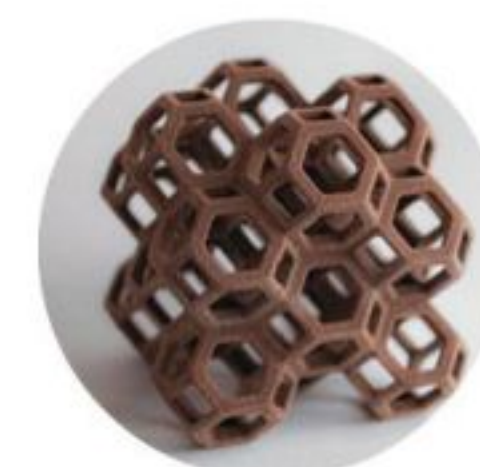
DAVE GERSHGORN

The ability to create food with the press of a lever has been a science-fiction staple for decades. While 3-D food printers have not reached *Star Trek* levels, they can make simple foods, and will soon be pressing and cooking your burgers. Here are a few new products—and a taste of what's to come.



Foodini, Natural Machines

Prints pasta, crackers, and burgers. However, the ingredients—such as ground beef—must be prepped and fed into the machine to be printed and then cooked separately. The next model is expected to cook as well.



ChefJet Pro, 3D Systems

Engineered to print intricate confections, like multicolored candies and wedding toppers. The ChefJet Pro uses powdered printing sugar in flavors such as chocolate, vanilla, mint, and watermelon.



3D Fruit Printer, Dovetailed

This doesn't aim for traditional foods. Instead, it prints "bespoke fruits" in natural shapes, textures, and tastes. It drips flavored liquid into calcium salt, which then forms in gelatinous fruit-shaped clusters, such as a raspberry.

LET'S TALK ABOUT

MARTIANS

We found the perfect excuse to geek out on exploring Mars—in science fiction and real life. And we invited the director of *The Martian* to join us.

INTERVIEW BY **Erik Sofge**



In The Martian, an astronaut (played by Matt Damon) is forced to survive alone on the Red Planet—here, simulated on a set in Budapest.



HOLLYWOOD

RARELY MAKES MOVIES LIKE *THE MARTIAN*.

It's a big-budget science-fiction film that's set in space but doesn't feature aliens, robots, or warp drives. The only villain is Mars itself, and the character who gets stranded there is a botanist (played by Matt Damon). *The Martian*, which opens on October 2, is about survival through science. To make that believable, director Ridley Scott strove to be accurate. We spoke with Scott and two consultants to his team—NASA's Dave Lavery and Andy Weir, the author of the book that inspired the film—about how one goes about creating the next chapter in human space exploration.

What was it about *The Martian* that appealed to you?

SCOTT: I discovered really quietly that I'm a science-fiction fanatic. For many years after having directed *Blade Runner*, I kept missing it. That's what made me climb back in with *Prometheus*. When the phone rang, I was reading *Prometheus 2*.

With *The Martian*, I was fascinated by what NASA will have to do. You can't just go to Mars and land and say, "OK, let's build

a house." You've got to get all that stuff up there. In effect, the first astronauts will have to be house builders. And how do you get it there? Do you drop it to the surface in balls and bounce it?

LAVERY: That's exactly the sort of thing we at NASA are constantly re-evaluating and redesigning as we prepare for the first human missions. Everything astronauts need to survive—from the atmospheric system to forks to eat with—will have to be provided. When you start wrapping your mind around that, you recognize it's a huge problem.

SCOTT: I guess spending billions to get a few plumbers up there is not very romantic, is it? You better have the water running before you get up there.

LAVERY: Our current thinking is to have the habitat placed and in operation before the astronauts ever leave Earth. Andy gets that right.

Is it challenging to remain scientifically accurate?

WEIR: It's hard to tell a compelling story and remain true to science, especially if you're talking about the real space program. Frankly, NASA's whole job is to keep exciting things from happening—to make sure there's not a panicked, "Oh my god we're gonna die" situation. It's more like: "OK, well, this thing broke. That's why we have four independent backups."

SCOTT: The book has so much research on how to survive anywhere. That was really the lifeblood of the story and the screenplay—the idea that this guy is Robinson Crusoe, as I saw it. How does he pull himself together when he gets stranded? It's intriguing to think about what you would do in that situation, given what's at your fingertips. It's all there to survive, provided you don't panic. Gradually the nuts and bolts come together through the mind of Mark Watney [Damon's character].

WEIR: Drew [Goddard, the screenwriter] and I went back and forth a lot on the screenplay. I really appreciate how close you guys stayed to it. I was surprised.

SCOTT: We also talked to NASA quite often. Our production designer visited and saw stuff like the new suits. I don't like your suits, by the way, dude. Jesus Christ, the puffiness. I think you're going to like our suits much better [laughs].

LAVERY: We have an ongoing program to try to understand what Mars suits will be like. One thing we realized a long time ago is that the Apollo-generation suits just are not suitable for a Martian environment. We're doing whatever we can to make the suits smaller and lighter, more flexible, more comfortable. The Apollo suits, for what we had at the time, were wonderful. But they are not going to work over weeks or months for long-term exploration.

SCOTT: I love the big white suits. We use those at the end. They're spectacular.

Our roundtable



- 1 Ridley Scott, director of the film *The Martian*
- 2 Andy Weir, author of *The Martian* sci-fi novel
- 3 Dave Lavery, program executive for solar system exploration at NASA

Let's Talk About Martians

Scott filmed certain scenes in Jordan's Wadi Rum desert; the Mars-like landscape didn't require special effects.

How realistic is *The Martian*?

LAVERY: One of the things that impressed me in the book is the effort to be technically accurate—correct about what resources are available, how problems would get solved. Even small details about the other spacecraft, like what might be available to scavenge and repurpose. It's obvious that a lot of research went into it. And I was happy to see that same treatment in the script. I was contacted several different times by Ridley's crew about, for example, what the *Sojourner* rover actually looked like. Where would things be positioned?

SCOTT: We reproduced the *Sojourner* and its mate. The thing is so beautiful. Why not just reproduce it?

LAVERY: The very first Mars mission that I worked on as a flight project was the *Sojourner* rover.

SCOTT: My god.

LAVERY: To be able to go back and talk about that and what it actually had on board was a lot of fun.

Were some details sacrificed for the sake of story?

WEIR: The two biggest inaccuracies in the book were: One, the inertia of a Martian sandstorm isn't large enough to cause damage to anything. And two, I do only a sort of hand-wavy lip service to radiation protection. I just vaguely say, "Oh yeah, all this stuff is shielded from radiation." But that's actually a huge problem in real life, and there's no easy solution.

SCOTT: I have him wrapping his radioactive generator in space foil like a giant Christmas present.

WEIR: [Laughs] That's awesome. I kept getting these questions filtered to me through a bunch of people, where Ridley was saying, "Hey, wait a minute, a dust storm on Mars would not cause this kind of damage." And I was like, "Yeah, you're right." I had an alternate beginning in mind for



the book that I ditched because it wasn't as exciting. It was an engine-test failure. I told Drew I could write that up with all the technical details. And he was like: "No, everybody is happy with the sandstorm. It looks really cool."

SCOTT: The storm is massive. We won't be reshooting that.

How do you think people will perceive space exploration after watching the movie?

LAVERY: I've been thinking about that quite a bit. The idea that this could be one of those go-to films that help people understand the realities of space exploration—in the same way, for example, *Apollo 13* did—is an exciting prospect. The book and the film also tell the human story, and that's important. The way the characters react and deal with enormous technical problems is very accurate.

I do have one question, related to that, for Andy. I was absolutely fascinated by the idea that Watney's skill centered on his role as a botanist. And I'm curious, as you developed the idea, did you start with, "Hey, I've got a botanist on Mars; how does he survive?" Or did you start with, "I've got a whole bunch of problems, and the perfect guy to solve them is a botanist?"

WEIR: The latter. If you're going to be on Mars for a long time, there's no way to survive without growing food. And rather than try to convince the reader that a pilot could successfully grow a bunch of crops in an adverse environment, I thought, "Oh, I

can say his scientific role is a botanist, and then no one will question anything plant-related he does from then on, right?"

SCOTT: We did an experiment to see how you might really grow food on Mars so we could show it as accurately as possible. We were growing spuds in a warehouse under lights like you'd grow marijuana [laughs].

LAVERY: I think the movie will reinforce the idea that this is something achievable. People will get an appreciation for what the astronaut experience is like. But I think even beyond that, people are also going to have a newfound respect for botanists.

Would you ever go to Mars?

SCOTT: I love the Earth too much. And I think the endless journey would get me down. Astronauts have to be perfectly balanced psychologically. I tip my hat to them.

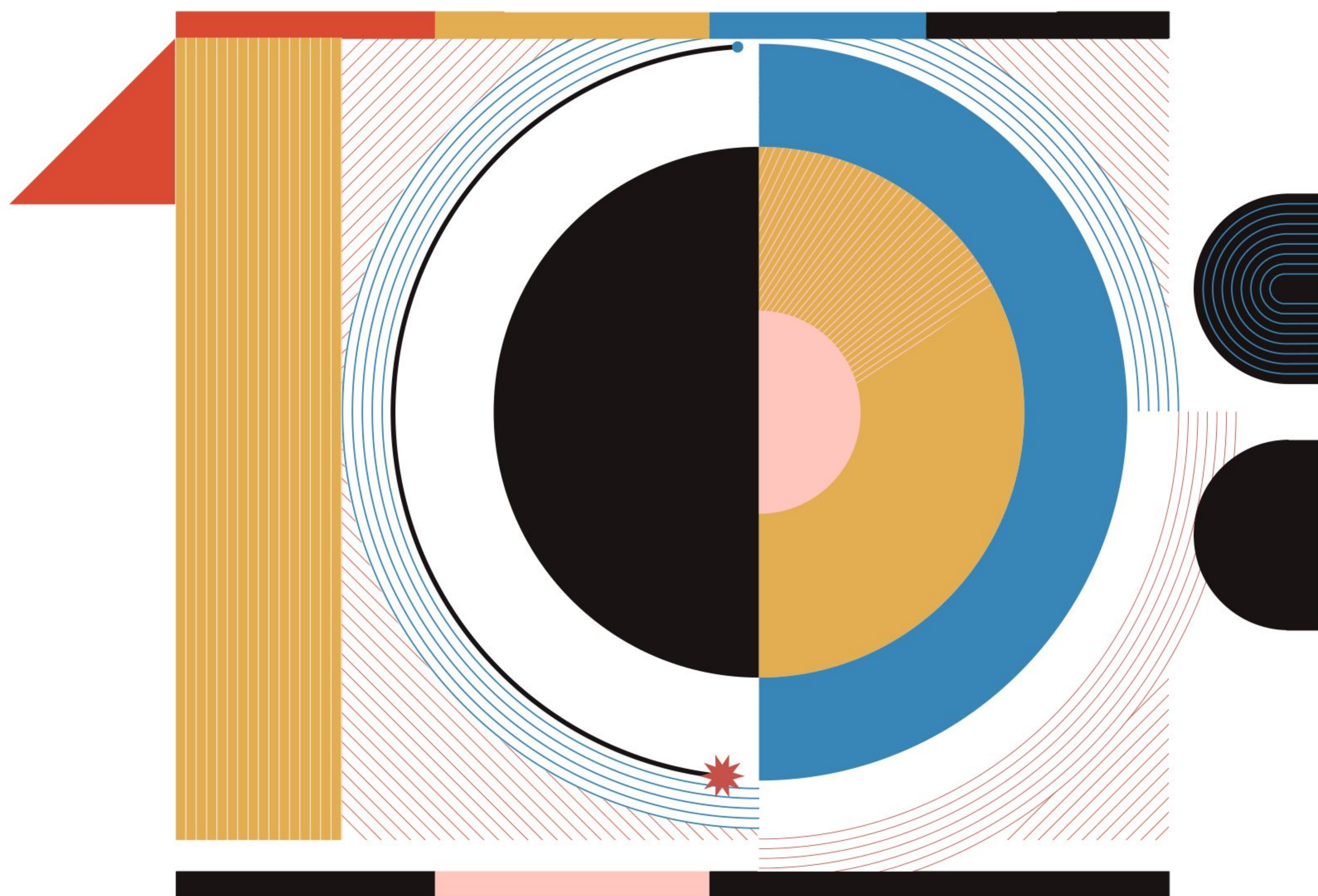
WEIR: Science fiction and popular culture have dramatically undersold the complexity of getting humans to Mars. People think: It'll be harder than the Apollo program but, c'mon, leaving Earth and going to another place, how hard can it be? Well, many, many orders of magnitude harder. That takes a level of bravery that is well beyond anything I would be willing to do.

LAVERY: I would actually want to go to Mars, with one big caveat: I would want to make damn sure that I get to come back [laughs]. I'm not interested in a one-way trip. But if I can come back, yeah, I would do it in a heartbeat. *P/s*



Kathryn Whitehead

THE BRILLIANT



**FOR THE 14TH YEAR, *POPULAR SCIENCE*
HONORS THE BRIGHTEST YOUNG MINDS RESHAPING
SCIENCE, ENGINEERING, AND THE WORLD**

by Veronique Greenwood & Cassandra Willyard

ILLUSTRATIONS BY **Alvaro Tapia Hidalgo**

TYPE DESIGN BY **Claudia de Almeida**



Brilliant 10



KATHRYN WHITEHEAD

Designs Drugs to Wipe Out Disease

/ AGE: 35

The human body is difficult territory to conquer, even for medicine: Many drugs have to enter the bloodstream, bypass the immune system, and arrive at a precise location within a designated cell. That's why Kathryn Whitehead, a chemical engineer at Carnegie Mellon University, is searching for the perfect vehicle: a nanoparticle that can shuttle new

therapies directly to where they're most needed.

Whitehead is focused on double-stranded bits of nucleic acid called small interfering RNAs (siRNAs). These molecules can block the production of many proteins that cause disease, and so can potentially treat everything from genetic disorders to viral infections. But siRNAs are unstable and difficult to deliver. While many researchers have tried encapsulating them with nanoparticles, they've struggled to find one that works successfully.

To identify the ideal delivery system, Whitehead employed a labor-intensive approach: Rather than tweaking the structure of a single nanoparticle bit by bit, she and her colleagues generated 5,000 novel ones, then tested the most promising in mice. "It sounds like a lot of work, and I suppose it was," she says. But the strategy enabled Whitehead to find nanoparticles she might have otherwise missed. "You just never know what's going to work well," she says.

By comparing the successes and failures, the team developed a model to predict the best particles. And they're now using their top candidate to develop therapies for non-Hodgkin lymphoma—drugs that target only cancer cells with specific mutations, hopefully ridding the body of disease with fewer harmful side effects.

Whitehead credits much of her scientific success to plain old perseverance; her lab's mascot is the honey badger, an animal known for its determination. "People look at me like I'm crazy when I say I tested thousands of materials," she says. "I think some others would have given up."

"I want the research I do to impact the way we manage the planet." —JACK GILBERT

JONATHAN PRUITT

Studies How (Spider) Societies Function / AGE: 29

Jonathan Pruitt's typical **workday** involves hours spent crouched in deserts and forests, observing the social lives of colony-building spiders. Like people, certain arachnids have different personalities—some are docile, some are aggressive—and Pruitt, a behavioral ecologist at the University of Pittsburgh, studies how these social traits affect survival. His findings provide the first evidence that individuals in the wild sometimes sacrifice their own genetic survival for the sake of the group—a topic of hot contention among biologists for 40 years.

Life as a spider is risky. Each year 60 to 90 percent of colonies collapse. "It's death, death, death—little carcasses blowing in the wind," Pruitt says. But he found that a colony's survival isn't purely a crapshoot: It depends on the ratio of docile to aggressive spiders. Colonies that have ample resources require more aggressive spiders to protect them, while colonies with few resources fare better with more

docile spiders that don't waste energy fighting each other. If the ratio isn't optimal, individual spiders will adjust it by sabotaging their own offspring. Those spiders with an undesirable trait will lay fewer eggs—ensuring that the group endures even at the expense of their progeny.

Though evolutionary models suggested that such group selection must be occurring, no one had found solid proof. Many claimed looking for it was a waste of time. Having proved the skeptics wrong, Pruitt is now looking for other situations where group selection matters. The search has implications far beyond a single species. "If we can show that this is a robust result that we get in other systems," he says, "we can improve our understanding of how societies work."

JACK GILBERT

Changes the World One Microbe at a Time / AGE: 38

Jack Gilbert wound up in microbiology because of ice cream. A food company hired him to look for substances to make frozen desserts smoother, a task that involved studying Antarctic bacteria. "It was a really noble cause!" he jokes. Now a microbiologist at Argonne National Laboratory and the University of Chicago, Gilbert samples bacteria from all kinds of ecosystems—both indoor and out—in order to better understand the unique roles they play. "I want the research I do to impact the way we manage the planet," Gilbert says.

In the pursuit of that goal, Gilbert's projects tackle problems as diverse as water treatment, crop productivity, and human disease. For example, he recently figured out why gut bacteria become more virulent after surgery—they lack phosphate, so giving patients phosphate can prevent post-surgical infections. Gilbert also found that people's homes take on the microbial signature of their bodies within 24 hours. He has a hunch those microbes can help repopulate the gut after a person has taken antibiotics.

To glean how microbes influence whole ecosystems, Gilbert's lab collects and models vast amounts of data—from homes, hospitals,





Alex Halderman



rivers, and air. Gilbert and his colleagues have even set out to characterize all of the microbes on the planet. For the Earth Microbiome Project, his team has so far identified some 22 million species from samples sent in by hundreds of people. They'll analyze the resulting database to learn how these bacteria might be harnessed to improve people's lives.

Gilbert is quick to point out that he makes such potentially powerful discoveries because of his collaborations. He regularly works with more than 500 scientists. "If you're willing to put energy and enthusiasm into actually talking with people and understanding what their problems are," he says, "man! Everyone wants to work with you."

MARYAM SHANECHI

Decodes the Brain to Unlock Its Potential / AGE: 34

Maryam Shanechi used to study wireless communications systems. Now she investigates a far more complex network: the billions of neurons that make up the human brain. Shanechi, a neuroengineer at the University of Southern California, is trying to crack the neural code to develop better brain-machine interfaces.

Existing devices simply translate the brain's electrical signals into movement, enabling paralyzed people to move a computer cursor or a robotic arm. Shanechi applies control theory. In other words, she decodes neural activity from many parts of the brain to provide more-precise control. Next, she wants to translate those algorithms into signals the spinal cord can understand so paralyzed patients can move their own limbs.

Her team is already making headway. Last year, they processed the neural activity of a monkey and translated it into spinal stimulation that moved a second, sedated monkey's hand. The system doesn't work perfectly yet, but Shanechi has recently developed a more accurate model that tracks the brain's activity by the millisecond. She's also working on algorithms to help the brain self-regulate, providing stimulation that alleviates depression or post-traumatic stress disorder. Decoding mood is even more difficult than deciphering movement, but Shanechi says, "That's what makes it interesting."

ALEX HALDERMAN

Strengthens Democracy Using Software / AGE: 34

In 2010, the District of Columbia decided to test its online absentee voter system. So officials held a mock election and challenged the public to do their best to hack it. It was an invitation that Alex Halderman, a computer-security expert at the University of Michigan, couldn't resist. "It's not every day that you're invited to hack into

government computers without going to jail," he says.

In less than 48 hours, Halderman and his students gained complete control of the system and rigged it to play the Michigan fight song each time a vote was cast. The students were ecstatic, but Halderman, who has a long history of exposing cybersecurity weaknesses, takes a more sober view. "This is the foundation of democracy we're talking about," he says. Since then, Halderman has been working with governments that allow e-voting to make those systems more secure. At the request of a government whistleblower, he took part in the first independent examination of India's electronic voting system. "India's machines were fairly easy to tamper with," Halderman says. This past year, he and his students replicated the system in Estonia, where 25 percent of votes are cast online, in their laboratory. They were able to introduce malware onto voters' computers and tamper with the server that produces the official count, proof that elections could be fixed.

Recently, Halderman has been developing software that exploits digital vulnerabilities for a different reason: It would allow citizens of countries like China and Iran to bypass government censors and access blocked sites. He released the newest version, called TapDance, last year and is talking with the U.S. Department of State about working together to further advance it. The Internet can be leveraged to strengthen democracy, Halderman says. But to do so, "we're going to have to solve some of the hardest problems in computer security."

"This is the foundation of democracy we're talking about." —ALEX HALDERMAN

ALPER BOZKURT

Turns Animals into First Responders / AGE: 36

In 2009, Alper Bozkurt went to see *Up*, an animated movie that features a talking dog. An electrical engineer at North Carolina State University, he had been developing instruments to control cockroaches for search-and-rescue missions. But the movie gave him a new idea: What if he adapted his work for dogs?

Canines have long been used for search-and-rescue, but disaster zones can hamper their abilities. Because handlers rely on audio and visual cues, dogs must remain nearby, limiting the area they can cover. Bozkurt decided to build a cross-species communications system that defies distance. It enables humans and dogs to work together to save lives, even when separated by rubble.

The system consists of a harness fitted with sensors. Some track the dog's vital signs and others monitor its movement, conveying the poses a dog strikes when it picks up a particular scent. The animal can hear cues through a speaker on the harness; it can also feel them through a series of vibrating motors near its skin.



The Brilliant 10

Ultimately, Bozkurt sees these cyberdogs as just one part of a more efficient search-and-rescue team, one that could include drones, robots, and cybercockroaches. "We are at the dawn of a new era, where everything that can be interfaced electronically has started to interact," he says. "My vision is to fuse biological organisms with synthetic electronic systems."

BHASKAR KRISHNAMACHARI

Networks Cars for Safer Roads / AGE: 38

When Bhaskar Krishnamachari moved to Los Angeles, he hadn't spent much time thinking about cars. But one gloomy day, he caught a news report about a 194-car pile-up. The fog hung so thick, drivers couldn't see the impending accident until it was too late. That disaster could have been avoided, Krishnamachari thought, if only cars could talk to one another.

A network engineer at the University of Southern California in Los Angeles, Krishnamachari envisions a future in which cars are bilingual—able to converse with cell towers, as some can today, but also with other vehicles through digital short-range radios. A car slamming on its brakes could send a warning to any vehicle within half a block in milliseconds. Such a system could also be used to disseminate data that needs to reach many vehicles, such as software updates. Once a subset of cars downloads it through the cellular network, the data would spread to others nearby.

Krishnamachari has been collaborating with General Motors since 2007 to develop vehicle-to-vehicle communication, and he has already tested it in a handful of cars. Last year, the team used GPS data from more than 600 taxis in Beijing to simulate how the system might work in a larger fleet. The U.S. Department of Transportation also considers vehicle-to-vehicle communication the future: It recently announced plans to require such devices in new cars. The technology could help pave the way for self-driving cars, or even teams of robots doing remote exploration or disaster response. Krishnamachari is designing a system that's flexible. "When you build a network," he says, "you don't want to build it for specific applications."

ZEV GARTNER

Builds Tissues That Snap Together Like Legos / AGE: 38

As a chemistry graduate student, Zev Gartner attended a biology class that changed his career. That's where he learned that the way cells are physically arranged in tissue can change how they behave—and whether they become

malignant. "That concept was fascinating," he says. Gartner now builds tissue in his lab at the University of California at San Francisco, where he's a chemical biologist. By more accurately reproducing how cells grow in the body, he hopes to learn why the structure of tissue is so important to human health.

Most methods for creating lab-grown tissue are imprecise, generating tiny samples that are all a bit different. Gartner developed a more elegant strategy: He exposes cells to pieces of sticky DNA that insert themselves into the cell membrane. Each of these DNA links attach only to others that complement its particular sequence. By varying the links, Gartner can assemble tissue layer by layer like Legos, in exact structures. This allows him to make thousands of samples that are nearly identical, down to the specific arrangement of cells.

As a result, Gartner can control experiments to a degree previously impossible, exposing identical tissues to different therapies. He can also study how tissue changes with disease. Gartner suspects that when cells become cancerous, the way they attach to each other morphs. So recently he built breast tissue with two cell types to study how they interact. "If we understand how cells assemble," Gartner says, "we can understand what it is that lets a tissue break down and become metastatic"—a new understanding of cancer itself.

"The whole village was covered with grasshoppers. They had eaten even the bark off the trees." —ARIANNE CEASE

ARIANNE CEASE

Prevents Biblical Plagues with Modern Data / AGE: 33

In 2005, Arianne Cease was a Peace Corps volunteer in Senegal when disaster struck: Her small rural village was attacked by locusts and other grasshoppers, destroying a year's harvest and the villagers' food supply. "The whole village was covered with them," she recalls. "They had eaten even the bark off the trees." Insect swarms regularly sweep across the globe, causing billions of dollars in crop loss. Cease saw that pesticides didn't seem to help. So when she left Senegal, she set out to find something that would.

Now a biologist at Arizona State University, Cease investigates what transforms individual locusts, which are harmless, into ravenous swarms that threaten the livelihoods of one in 10 people on the planet. She leads a research network that includes biologists, economists, and geographers who study a diverse range of possible factors, from the metabolism of a single locust to the international agreements that govern livestock markets.

In China, her team made a surprising discovery: Overgrazing land can cause locusts to swarm by depleting the nitrogen level in the soil and grass. Locusts, it turns out, prefer a low-nitrogen diet, and in crowded conditions, that flips a switch in the insect's behavior. They also found that

CONTINUED ON PAGE 72 →

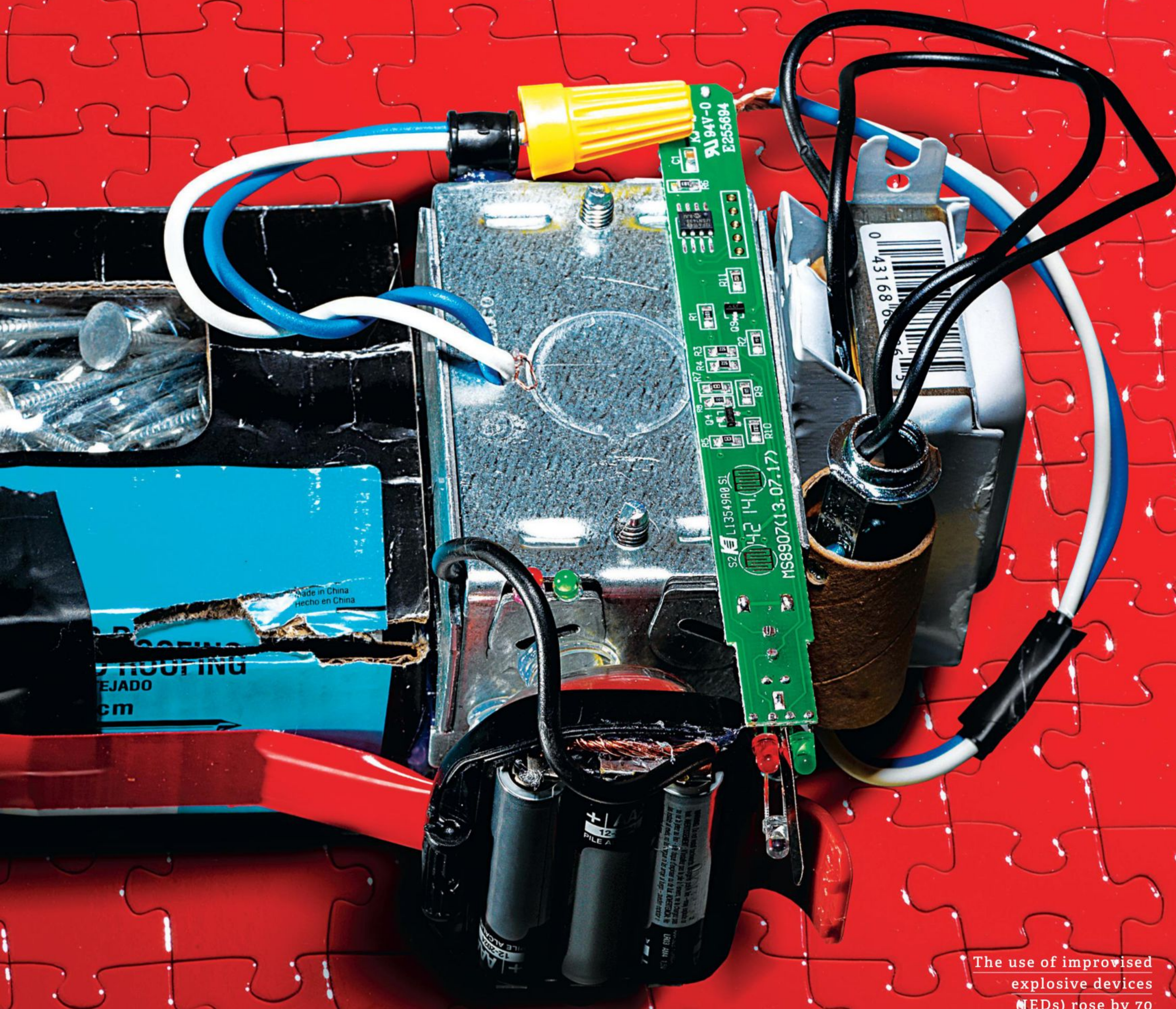


TO CATCH A BOMB- MAKER

In April 2009, an Iraqi refugee arrived in America ready to make a new life. No one suspected he was an Al-Qaeda operative. This is the story of a little-known FBI forensics lab and how it changed the war on terror.

By Clay Dillow

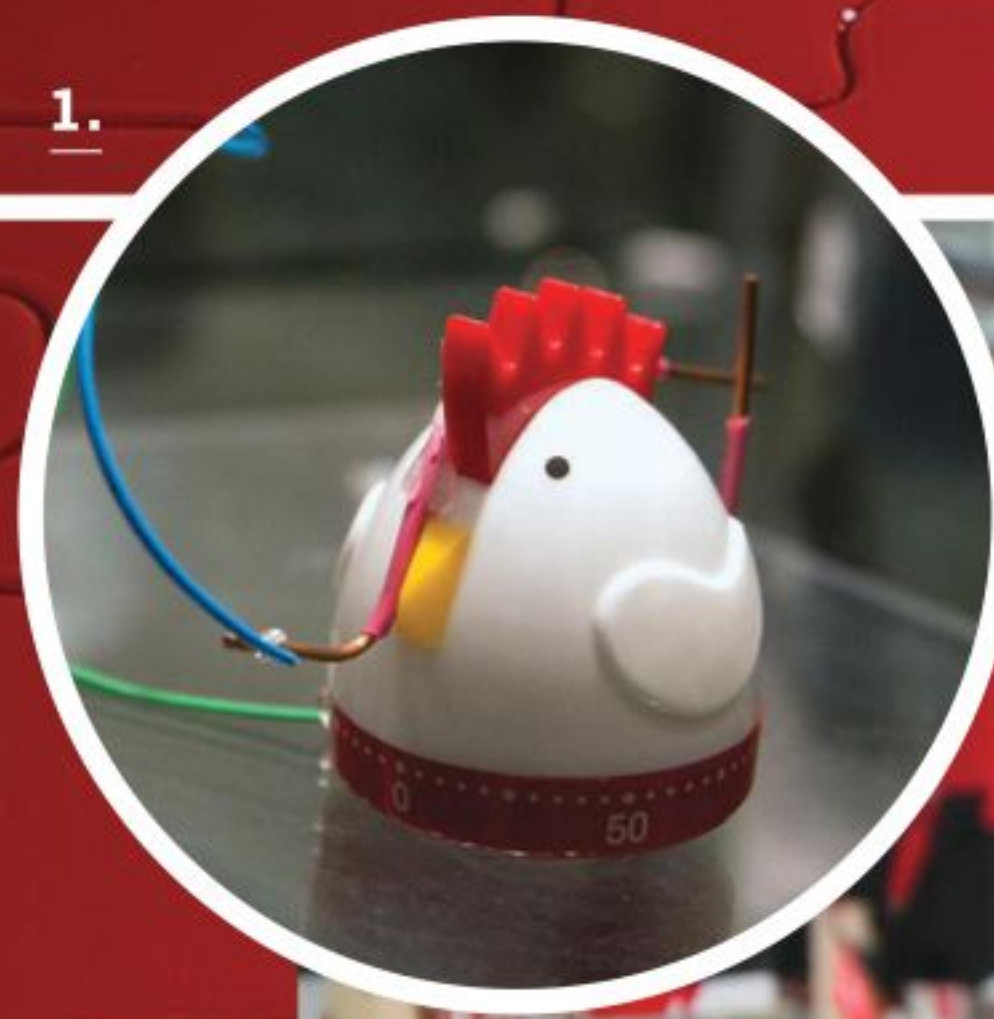




The use of improvised explosive devices (IEDs) rose by 70 percent between 2011 and 2013; 66 countries suffered attacks, some on a near-daily basis.

1.

2.



THE INSURGENT BEGAN WITH A CORDLESS PHONE—

one of the knockoffs of a Chinese-built Senao so popular in northern Iraq. Hunched over a worktable somewhere near the refinery town of Baiji, about 150 miles north of Baghdad, he methodically worked through a series of steps by now both familiar and frighteningly simple.



Loosen the screws on the base station. Remove the plastic casing, rip out the power cord, and replace it with a battery. Rewire the phone's page function to an external relay switch, then connect the relay to a battery and any mix of violent chemistry—plastic jugs full of diesel and fertilizer, a pressure cooker packed with homemade explosives, one of the many artillery shells available in post-invasion Iraq. When complete, pressing the page button on the phone's handset—even from miles away—will flip the relay and trigger the bomb.

During the conflicts in Iraq and Afghanistan, improvised explosive devices (IEDs) became the single deadliest weapons on the battlefield. In Iraq alone they accounted for between half and two-thirds of all U.S. wartime casualties and killed tens of thousands of civilians. They have now become a staple of insurgencies worldwide. But back in 2005—when the bombmaker sat poring over his Senao—the U.S. military was only beginning to understand the threat they posed.

In the waning days of August that year, insurgents concealed the modified Senao in a gravel heap south of Baiji. They then wired it to three artillery shells buried in a road several feet away. The bomb was presumably meant for one of the patrols that frequented the route, but on Sept. 1, 2005, U.S. forces discovered it before it detonated. A bomb-disposal team neutralized the explosives and then packed the Senao into a crate destined for a little-known FBI forensics lab operating out of a parking garage in northern Virginia. No one knew at the time that the IED was anything more than just another in a flood of roadside bombs. Instead it would end up unmasking a terrorist and helping FBI analysts pioneer techniques that have foiled criminal plots around the globe.



In the heavily wooded grounds of Marine Corps Base Quantico in eastern Virginia, special agent Greg Carl leads the way into an imposing building and down a windowless hallway. Swinging open a pass-code-secured metal door, he steps into the warehouse that contains the FBI's Terrorist Explosive Device Analytical Center (TEDAC). A row of white boxes, each 4 feet by 4 feet, runs down the center of the room. Others line the 115-foot-long walls, each one bar-coded, inventoried, and packed with IEDs.

Carl is TEDAC's director, and this space—tucked in the bowels of a garage adjacent to the FBI's main forensics lab—is intake. More than 100,000 IEDs have passed through here since the lab opened in 2003. Some arrive inert but intact, others in post-detonation fragments. Lab technicians analyze each one and catalog it in TEDAC's database,

To Catch a Bombmaker



1. IEDs take many different forms: big or small, wireless or analog. The FBI's TEDAC lab serves as a clearinghouse for them all.

2. Some IEDs arrive at TEDAC as bomb or trigger fragments, while others arrive as complete, albeit neutralized, devices.

3. Analysts photograph each IED in ultrahigh resolution and store that image in a digital reference library.

creating what has become the world's largest bomb library.

In the field, an IED is an anonymous threat. But at TEDAC, it gains context. By comparing physical evidence along with the IED's location, design, and materials, investigators can draw connections between bombs and bombmakers. They might trace multiple IEDs to a single factory—or even a single individual. They might identify new trends or techniques. And they can continue to analyze evidence for years, tracing bombmakers and their apprentices through time.

“Up until TEDAC, the Department of Defense didn't understand the benefit of having forensics on the battlefield,” Carl says. “But fighting insurgencies is more like fighting organized crime. It's a conspiracy.”

In 12 years, analysts using TEDAC data have tied more than 2,700 suspects to possible terrorist activities, and nominated more than 350 to the terrorist watchlist. The lab has collected and shared 80,000 fingerprints with law-enforcement agencies around the globe. It has been so successful and grown so rapidly that this summer the FBI began moving 250 TEDAC staffers out of the improvised headquarters into a \$132 million facility in Huntsville, Alabama.

That's today. In 2003, the center looked much more like a startup. The focus was mostly on Iraq and Afghanistan, and the staff was composed of just a few dozen analysts—many borrowed from other FBI labs. Then the Iraqi insurgency took off. What started as a few IED deliveries a month turned into hundreds, then as many as 2,400. That's how TEDAC ended up working out of a parking garage, Carl says. The lab had to grab whatever space it could.

By the time the Baiji bomb arrived in late 2005, TEDAC's analysts were mired in a massive backlog of evidence. Tens of thousands of devices awaited examination. The Baiji bomb was still among them when, in 2010, an unusual request landed on the desk of forensic scientist Katie Suchma. The query had originated not in Kabul or Kirkuk but in Kentucky. FBI agents there had become increasingly nervous that an Iraqi refugee recently resettled in the college town of Bowling Green was actually an operative for Al-Qaeda in Iraq (AQI). They made a simple but urgent request: Tell us everything you can find out about Waad Ramadan Alwan.

“FIGHTING INSURGENCIES IS MORE LIKE FIGHTING ORGANIZED CRIME. IT'S A CONSPIRACY.”

In early 2007, the U.S. State Department launched an ambitious program to resettle tens of thousands of Iraqis—many of whom served as interpreters or fixers for U.S. forces and faced reprisals from militant groups—to new homes in the U.S. Waad Ramadan Alwan was among those who applied. After passing a State Department vetting process, he received a visa and assistance in moving to Kentucky in April 2009.

In Bowling Green, Alwan lived with his wife in a simple apartment and worked at a chicken-processing plant. By all appearances, he led a normal life. So when the FBI received a tip in September 2009 indicating that Alwan might be an AQI member, it wasn't immediately clear that the intelligence—the details of which the FBI won't discuss—was accurate.

Agents at the FBI's Louisville field office mounted some standard surveillance but soon moved on to a full-blown investigation. They arranged an introduction between Alwan and an FBI informant posing as a fellow refugee sympathetic to the AQI cause. Alwan was a little cagey at first, but by early 2010, something changed. He began to talk about his past.

“He starts saying things that make the hair stand up on the back of your neck,” says FBI supervisory special agent Tim Beam, of the Louisville field office. “He starts talking about participating in attacks on U.S. troops in Iraq. He's talking about building bombs.”

While Alwan's bragging seemed to validate the FBI's intelligence, agents couldn't be sure: Was he a hardened AQI militant responsible for attacks on U.S. soldiers abroad or simply a boastful Iraqi looking to impress a new



friend? If he was AQI, was he working alone or as part of a network of militants secretly plotting attacks on U.S. soil?

In order to find out, FBI agents set up a sting operation. The informant told Alwan he had friends in the U.S. willing to send cash and weapons to insurgents in Iraq, but he needed someone with contacts to facilitate. Alwan agreed to play middleman. In the first half of 2010, Alwan made regular trips to a storage unit in Bowling Green in which hidden cameras captured him preparing to ship a litany of weapons—Russian PK-model light machine guns, rocket-propelled grenades, sniper rifles, C-4 explosives, and even shoulder-fired Stinger anti-aircraft missiles. (All of the weapons were rendered inert by the FBI before being furnished, and the bureau maintains no money or weapons ever left the country.)

With that evidence, agents had grounds to charge Alwan with material support of a terrorist group. But by late spring of 2010, investigators were increasingly convinced that Alwan had indeed acted against U.S. troops in Iraq. In taped conversations, he boasted of building dozens of IEDs. He said he'd fired on U.S. troops with a sniper rifle. FBI agents claim he said that he'd had American soldiers "for lunch and dinner."

The FBI wanted justice for those soldiers. Moreover, if agents could prove Alwan was responsible for attacks on U.S. forces, they could bring far more serious charges against him—charges that could make him a valuable intelligence source during plea negotiations. But finding hard evidence against Alwan years after the fact—and in a war zone on the other side of the world—was a monumental challenge. Agents reached out to TEDAC for help.

When an IED arrives at TEDAC, it undergoes something of an entrance exam. First, a lab technician unpacks the device and creates an examination plan based on its type and the type of evidence that might be salvageable. Then techs photograph each IED, inside and out, at resolutions so high that individual characters stamped on microchip components are visible. Those images go into

TEDAC's database, where investigators or bomb technicians at partner agencies around the world can access them.

That visual record is vital, Carl says. The way a bombmaker has soldered a joint or twisted a wire can reveal if he or she is left- or right-handed. Certain techniques or constructions can serve as a signature for an individual or a group of bombmakers. "Maybe we can't definitively say, 'This person built this IED,'" Carl says, "but we can tie it back to a certain bomb factory."

All devices then move on to other stages of analysis. Some go to the FBI's tool-marks lab, where forensics experts look for unique,

microscopic markings left by specific tools or machines. If the bomb remains wholly or partially intact, engineering specialists break down its construction, logging those distinct aspects that could serve as

THE TERRORIST BOASTED OF BUILDING DOZENS OF IEDS. HE SAID HE'D HAD AMERICAN SOLDIERS FOR LUNCH.

a bombmaker's signature. Biometrics specialists scour devices for fingerprints or trace DNA that could tie an IED to bombmakers.

When Katie Suchma received the request to hunt for intelligence about Alwan in 2010, the majority of TEDAC's inventory had not been through these more advanced stages of analysis. "They wanted us to run this one guy's fingerprints against everything we had," Suchma says. "It was a needle in a haystack."

Slowly she and her team of more than 35 analysts began to winnow down the search options. Through the informant, the FBI had a rough idea of where Alwan was between 2004 and 2006, so that limited the number of target IEDs by geography. The team pulled 170 relevant boxes of evidence that represented 1,300 IED events and got to work. The FBI also had copies of Alwan's fingerprints, so the TEDAC team focused on recovering physical evidence when they could.

In November, agents caught a break when Alwan offered to show the FBI's informant how to build an IED. Alwan drew a few sketches detailed enough to give TEDAC's analysts insight into the type of device they were looking for. In December, the search narrowed further when FBI intelligence analysts digging into Alwan's past told TEDAC to focus on bombs from in and around Baiji.

By this point, Suchma and her team were already closing in, and in

To Catch a Bombmaker



1. Neutralized IEDs or IED fragments arrive at TEDAC as criminal evidence.

2. Today no evidence waits longer than 150 days for processing.

3. Greg Carl, the director of TEDAC, is transitioning the lab from its focus on Iraq and Afghanistan to a “rest-of-the-world” mission.

January, she sent a message to FBI headquarters in Washington D.C. They could stop wondering about Alwan. Two fingerprints lifted from an IED recovered near Baiji in 2005 were a match.

The FBI did not arrest Alwan immediately. Through the spring of 2011, agents continued to monitor him. They hoped to learn more about his AQI connections and any other IED incidents they could connect to him. By May, though, it appeared that they had learned all they could, so they decided to end the operation. A SWAT team moved in on Alwan and an accomplice during another phony arms transfer, arresting both.

The story of the AQI bombmaker arrested in suburban Kentucky made headlines for a few days but then was eclipsed by an even bigger news event: the death of Osama bin Laden in a compound in Abbottabad, Pakistan. Alwan's story quickly faded from view.

Quiet though it was, Alwan's arrest was a significant victory. The FBI was able to bring a 23-count indictment against him, including charges of conspiring to kill U.S. nationals abroad, conspiring to use a weapon of mass destruction (explosives) against U.S. nationals abroad, and distributing information on the manufacture of IEDs. Confronted with the evidence gathered by TEDAC, Alwan pleaded guilty. He confessed his AQI affiliation and cooperated with FBI agents in exchange for a reduced sentence. The agency won't disclose the precise information that he divulged as part of his cooperation, but he ended up with a 40-year prison sentence. The accomplice arrested alongside him is in for life.

Perhaps of greater consequence, Alwan's case changed how TEDAC conducts forensics. Techniques pioneered by Suchma's team to quickly analyze the evidence in Alwan's case helped TEDAC analysts rip through a backlog of tens of thousands of unexamined devices. A process many thought would take a decade or more took just five years. Now, no device sits unanalyzed for more than 150 days. “Alwan was the watershed moment, that's when we knew we had to get through this as quickly as possible,” Carl says. “That's what motivated us to find creative ways to

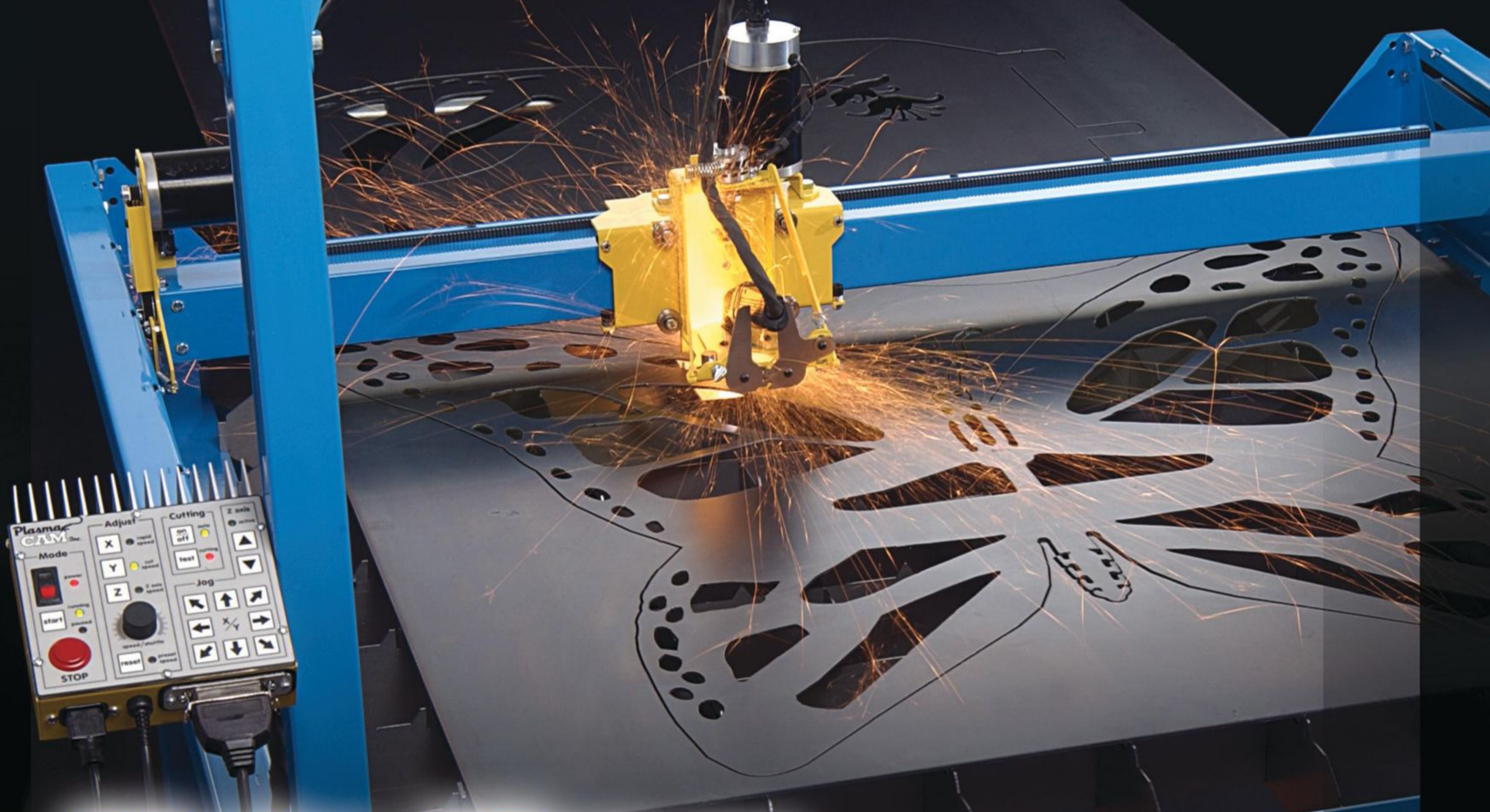
“THEY WANTED TO RUN THIS ONE GUY'S FINGERPRINTS AGAINST EVERYTHING WE HAD. IT WAS A NEEDLE IN A HAYSTACK.”

work through it.” The quicker TEDAC analysts can process IEDs, the more likely law enforcement agencies in the U.S. and abroad will find bombmakers before they strike again.

Clearing the vestiges of Iraq and Afghanistan from its inventory was symbolic for TEDAC. Today the center is pivoting from warfighter support in Iraq and Afghanistan to what Carl describes as a “rest-of-the-world” mission. Now, an IED recovered in the Philippines or Turkey will get the same treatment as a bomb discovered in Baiji. Also, acting in partnership with local law-enforcement agencies, TEDAC has become a global dragnet for bombmakers. For example, in September 2014, Scotland Yard arrested a suspected AQI bombmaker living in northwest London. The intelligence came from TEDAC and an IED recovered in Iraq in 2007.

Moving out of the parking garage at Quantico will no doubt give TEDAC a boost. In Huntsville, the lab will have more talent to draw from; both NASA and the Pentagon maintain major research facilities there. More important, it will have the room it needs to grow. The more bombs TEDAC analysts collect, the richer the data becomes and the more effectively they will be able to identify terrorists and criminals.

As global conflicts increasingly involve stateless actors drifting across borders from one battlefield to the next, TEDAC provides a form of institutional memory—a way of tying past acts to individuals in the present, no matter where they go. A decade from now, conflicts in places like Libya, Syria, Iraq, Nigeria, Yemen, and the Philippines will hopefully be distant memories. The world might move on, but TEDAC will continue connecting the dots, remembering what everyone else forgot. *PS*



Make Money in Metal Art



"I designed and cut this bench from an actual butterfly photo. My machine paid for itself in 3 months making products like these."



-Ken Garcia, PlasmaCAM® machine owner

Call with this code **3DCRK** for your free video & catalog showing lots of amazing projects you can cut on this robotic machine.

PO Box 19818 • Colorado City, CO 81019-0818
(719) 676-2700 • www.plasmacam.com

**Plasma
CAM** Inc.

EDITED BY *Sophie Bushwick*

STATS

Time 1 hour

Cost \$30

Difficulty

● ● ● ● ●



**FRIGHT
LIGHT**

Build a Flameless Hack-o'-Lantern



It's never a good idea to leave a flame unattended—even on Halloween. But that doesn't mean you have to give up the glow of a traditional jack-o'-lantern. You can create a realistic fire effect by wiring up an electronic

blinky light. This one, inspired by our friends at DIY blog Evil Mad Scientist Laboratories, uses a safe circuit that requires no soldering. It incorporates six LEDs with a candle-flicker effect, which will shine all night on three AAA batteries. And thanks to a phototransistor, which detects light, the LEDs will automatically turn off at dawn and back on at sunset. Trick or treat! **SEAN MICHAEL RAGAN**

continued on page 62 →

Build It

continued from page 61

200

Estimated residential fires caused by open flames in the U.S. each year around Halloween



MATERIALS

- Mini breadboard
- 6 candle-flicker LEDs
- 2 red and 4 yellow
- 6 100-ohm resistors
- 2 NPN transistors
- Infrared phototransistor
- 5-kilohm resistor
- Jumper wires
- 3 AAA
- battery box with switch
- 3 alkaline AAA batteries

TOOLS



Side-cutting pliers



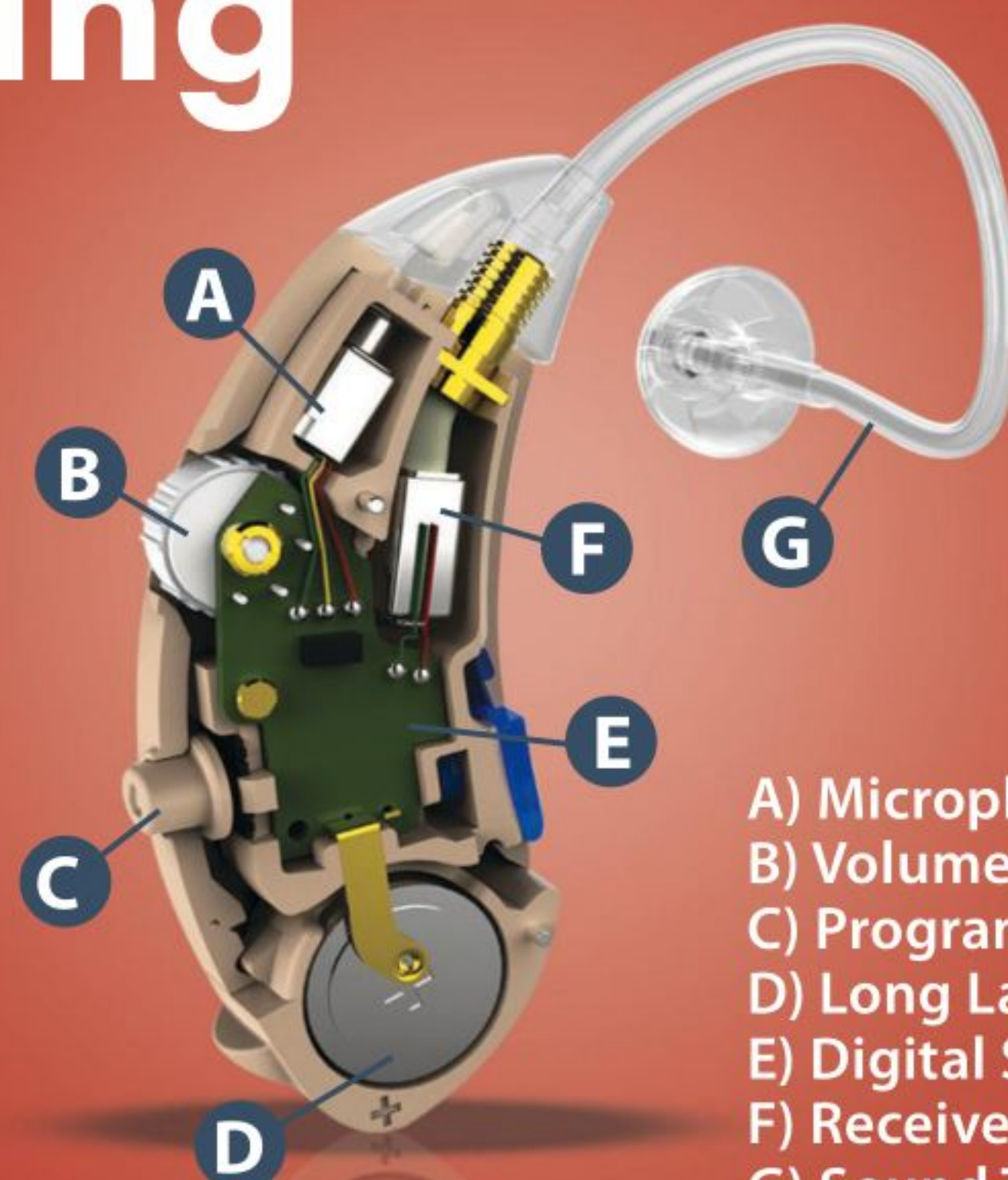
Wire strippers

INSTRUCTIONS

- Assemble the components and jumper wires in the breadboard as shown in the illustration. The LEDs, NPN transistors, and phototransistor (which looks like an LED with a black lens) are "polarized," meaning the circuit won't work as intended if you install them backward. For the four LEDs nearest the switch, place their "flat" sides facing away from the switch; the flat sides of the other LEDs and the phototransistor should face toward it.
- Trim the leads and jumper wires with the pliers as you go so everything sits flush against the breadboard face.
- Peel the film off the adhesive on the back of the breadboard and stick it to the battery box, right below the switch.
- Connect the red battery-box wire to the breadboard corner nearest and left of the switch, and the black wire to the far left corner.
- Load the batteries into the box and turn on the switch. If the LEDs don't come on right away, try covering the phototransistor with your thumb or moving the breadboard into a dark room. The sensor responds to sunlight and bright incandescent bulbs, but not to LEDs or fluorescent lights.
- Set the project inside your carved jack-o'-lantern and place it on an open patio or windowsill. If your carving is fairly open and admits natural light into the pumpkin, the phototransistor should easily detect when the sun sets. But if your pumpkin is dark inside, you might need to leave the lid off to prevent the LEDs from turning on too early in the day.
- Another option is to adjust the circuit's light sensitivity by replacing the 5-kilohm resistor. Swapping it for a stronger resistor (up to 10 kilohms) creates a circuit that turns on only at brighter light levels. A weaker resistor (down to 1 kilohm) makes a circuit that can turn on in dimmer conditions.

Affordable Hearing Aid Technology Only \$299!

Learn about our great digital technology at an affordable price.



- A) Microphone
- B) Volume Control Wheel
- C) Program Button
- D) Long Lasting Battery
- E) Digital Signal Processor
- F) Receiver (Speaker)
- G) Sound Tube

The All New HCX!

- ✓ Digital sound processing chip provides crystal clear sound and makes speech easier to understand without feedback
- ✓ Multiple memory programs adapt to most listening situations
- ✓ Nearly invisible thin tube design
- ✓ Helpful low battery warning so you are never caught unprepared
- ✓ Long lasting size 13 batteries
- ✓ 10 bands of layered noise reduction helps to emphasize voices while balancing out background noise
- ✓ 100% Money Back Guarantee



★ Customer Reviews ★

"I will definitely recommend your company to my patients."

- Dr. Arun P.

"We had no idea it would be such a fast, simple and enjoyable process Thank you..."

- Monique S.

Studies Show: Hearing Aids MAY HELP Prevent DEMENTIA.

A study by Dr. Frank Lin at the John Hopkins University, found that patients with only mild hearing loss were two times more likely to develop dementia. Fortunately, hearing aids help address hearing loss and may help prevent cognitive health due to hearing loss.

Digital Hearing Aid Technology... For Only \$299!

All hearing aids work the same way. The **microphone** picks up the sound and sends an electrical signal to the digital signal processor. The **digital signal processor** is the "brains" of the hearing aid. It takes the sound it receives and adjusts the sound to amplify important speech sounds as well as filtering out unwanted noise. (To ensure the best in quality, our digital processor is designed and manufactured right here in the **United States**.) Once the processor has amplified the sound, it is passed to the **receiver** (also known as the speaker) which emits a corrected and amplified sound through the **sound tube** into your ear.

Most importantly, your new HCX hearing aids work at a **fraction of the cost** of name-brand hearing aids. In addition to the technical components of the hearing aid, you also have a **volume control** that can be modified with a light touch of the finger. Your new hearing aids come with **3 different audio programs** that help you listen in different sound environments. You will love the Open-fit design, that is so light you probably won't even feel that you are wearing your hearing aids – you'll just be hearing clearly!

You can spend thousands for a high-end hearing aid or you can spend **just \$299** for a hearing aid that just plain works (**only \$274 each when you buy a pair**). We are so sure you will love our product, that we offer a **100% Money Back Guarantee - Risk Free** if you are not satisfied for any reason. It's time to get great digital technology at an affordable price!

BUY A PAIR AND SAVE \$50!

1-888-467-9375

Free 1 Year Supply Of Batteries!

***Use Coupon Code When You Order: P50**

Visit Us: www.AdvancedHearing.com/P50



The HCX



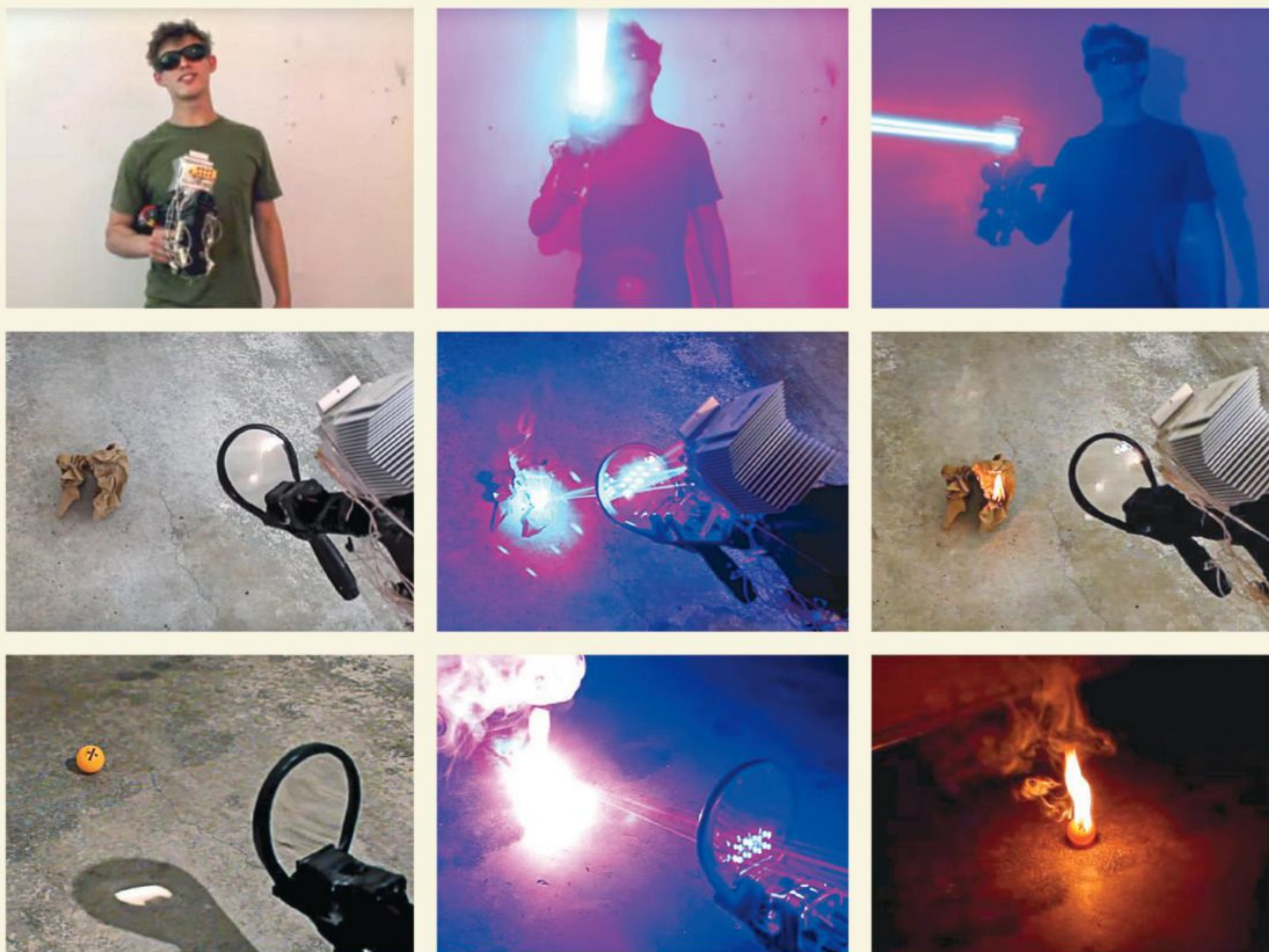
Enviably Project

A Laser Shotgun. Really.



There's no real reason a 40-watt laser shotgun should exist. But building one isn't illegal, just challenging. So this past June, Drake Anthony, then a college junior, gave it a go.

Rather than make a laser gun with a single powerful beam, Anthony decided to combine eight parallel 5-watt lasers. A lens would focus the beams to produce a concentrated blast of photons—similar to how a shotgun's choke controls the spread of pellets. During a break from his busy schedule at Southern Illinois University, the chemistry-math-physics triple major worked for two days, stripping wires, soldering parts, and troubleshooting bugs. The effort paid off. His 40-watt shotgun can set paper on fire, melt Ping-Pong balls, and burn wood.



"It's very, very strong and extremely dangerous," Anthony says. "But once I realized it was possible to make it, I had to try."

Anthony—better known to his 170,000 YouTube followers as styropyro—has been hacking lasers since he was 12 years old. Now 23, he has built and documented more than 100 homemade lasers and laser devices, such as lightsabers and lava lamps. The videos of his exploits helped him score a job in a physical chemistry lab at his university,

WARNING: Anthony's laser projects can be very dangerous. So don't try this at home—you'll scorch your eye out.

where he uses lasers to make MRI instruments more sensitive.

Now that he's a senior, Anthony is debating what to do for his life's work. He only knows he wants it to be equally crazy. "Ridiculous, high energy—just crazy!" he says. "So there's a good chance that lasers might be involved." **RACHEL NUWER**

Toolbox

FLEX YOUR MAKER MUSCLES



In 2006, undergraduate Brian Kaminski was building his senior design project: a glove to help stroke victims regain hand function. He needed a sensor to detect the electrical impulses sent to muscles, but he couldn't find one for less than \$1,000. Kaminski dropped the glove project, but the idea of a cheap muscle sensor stuck with him. Five years later, he created one. "I decided to hand-solder a few circuit boards and put them up for sale, thinking I would get only a few orders a month," Kaminski says. He was

To use "bionic claws," snap electrodes to the MyoWare sensor, and stick them on your arm. Then flex and—SNIKT!

soon scrambling to keep up with demand.

The current version of Kaminski's device, called MyoWare, reads the electric potential in a muscle through electrodes stuck to the skin. Based on how hard the muscle is flexing, the sensor increases the signal sent to a microcontroller chip, which can trigger an action. To demonstrate, Kaminski built Wolverine claws that shoot out when he flexes his arms. MyoWare is available through the website for his company, Advancer Technologies. **DAVE GERSHGORN**



Biotech Opens Up

GENE
REMIXER



In 1999, 19-year-old Sean Ward created one of the first music-recommendation algorithms, dropped out of the University of Virginia, and started his own company. By age 25, he had tired of the conflict between record companies and Internet users, so he turned to something completely different: bioengineering.

"In many respects, genetic engineering is the ultimate remix technology," Ward says. Bioengineers copy DNA from one organism and adapt it for another to create life-forms that change color, glow, or produce new medicine or materials. In today's high-speed, high-volume biolabs, automated tools like pipetting robots do most of the work—and each requires different kinds of code. Ward saw that, like music, biotech research had become digital. And also as with music, he could use his programming skills to give more people access to it.

This past November, Ward's company, Synthace, released Antha, the first open-source programming language that works across different biotech machines. Anyone who can code can write commands in Antha to direct all of a lab's equipment. This allows researchers—or programmers with a yen for genetic engineering—to more easily perform complex experiments, and share how they did it.

Ward was one of the first to see the potential of DIY genetic engineering, but he's not the last. Other companies are now producing tools that make it possible for amateurs to create new organisms—or, in Ward's words, to "program the assembly of matter." **DANIEL GRUSHKIN**

Three Tools for DIY DNA

ON THE COMPUTER

Arcturus BioCloud allows beginners to design basic bioengineering experiments through an online interface. The service sends the directions to a pipetting robot at a remote lab and then displays the results. **\$80 and up**

IN THE KITCHEN

Using kits from Synbiota, home hobbyists can start engineering color-generating *E. coli* with little more than pipettes, tubes, and the kitchen sink. **\$395 and up**

AT THE HACKERSPACE

OpenTrons produces a pipetting robot 10 times cheaper than conventional machines. Biohackers can download instructions for an experiment, calibrate the robot, and then simply hit "run." **\$3,000 and up**

USE AN ELECTRIC TOOTHBRUSH TO...

GOOD IDEA

SAND THE SMALL STUFF

Last June, professional DIYer Kip Kedersha turned an electric toothbrush into a \$5 mini power sander. Kedersha, who posts how-to videos on his YouTube channel, Kipkay, first cut the bristles off an Oral-B electric toothbrush. Then he hot-glued a small plastic circle to the head and attached self-adhesive sandpaper. The sander can make small cuts or grind fine details on plastic models or miniatures. "It fits the bill for a hobbyist," Kedersha says, "and it's a deal."

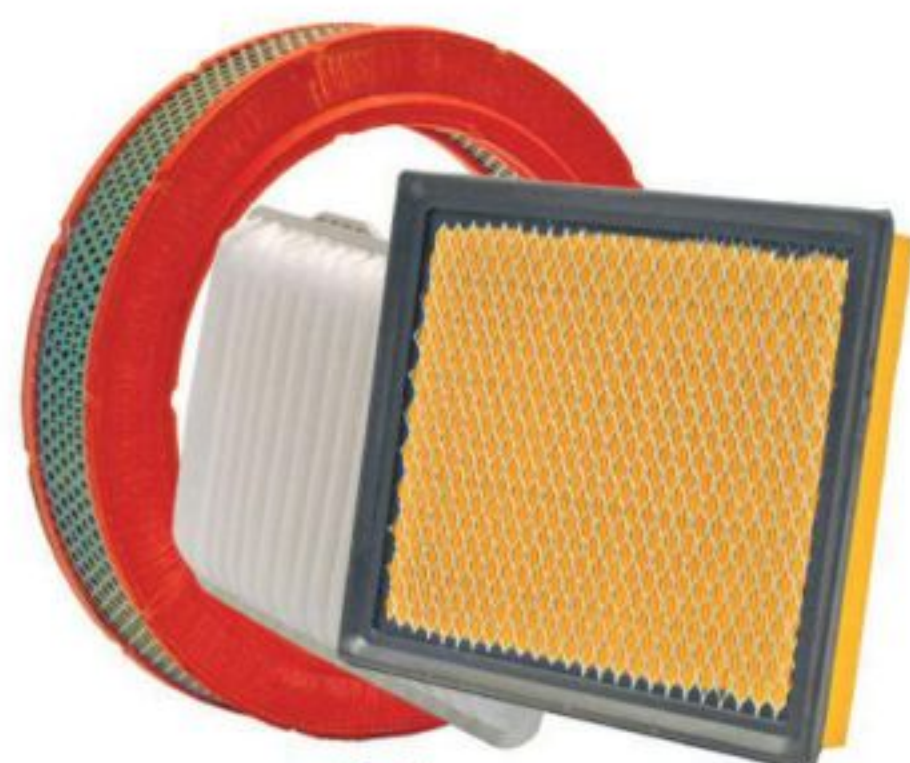
BAD IDEA

GIVE A TATTOO

Daring inkers have discovered that an electric toothbrush can also drive the needle of a DIY tattoo machine. But it's hard to control the needle's depth, which increases the risk of serious infections and scars. "There's nothing good about getting a toothbrush-machine tattoo, nothing whatsoever," says professional tattoo artist Gerald Feliciano. "You can buy almost any rinky-dink machine that will work better than that." LEVI SHARPE



ILLUSTRATION BY CHRIS PHILPOT



✓Yes



✓Yes



xNo



✓Yes



✓Yes



✓Yes

- ✓ Reliably Low Prices
- ✓ Easy To Use Website
- ✓ Huge Selection
- ✓ Fast Shipping

www.rockauto.com

RA
ROCKAUTO.COM
ALL THE PARTS YOUR CAR WILL EVER NEED

Bookmark**FOUNDRY**

When Foundry launched in March, Ryan Craven used the project-sharing website to show off the hoverboard he'd built in 2014. Rather than asking for step-by-step instructions, like other DIY sites, Foundry prompted Craven to describe his inspiration (*Back to the Future Part II*) and the challenges he faced ("many long bike rides to and from Home Depot in the hot Texas sun").

"Foundry is for people who want to sit down and learn the stories behind the creations," says founder and CEO David Endler. Eventually, Endler hopes the site will create a connected community of entrepreneurs, becoming a professional network for the maker movement. **REBECCA HARRINGTON**

Defined

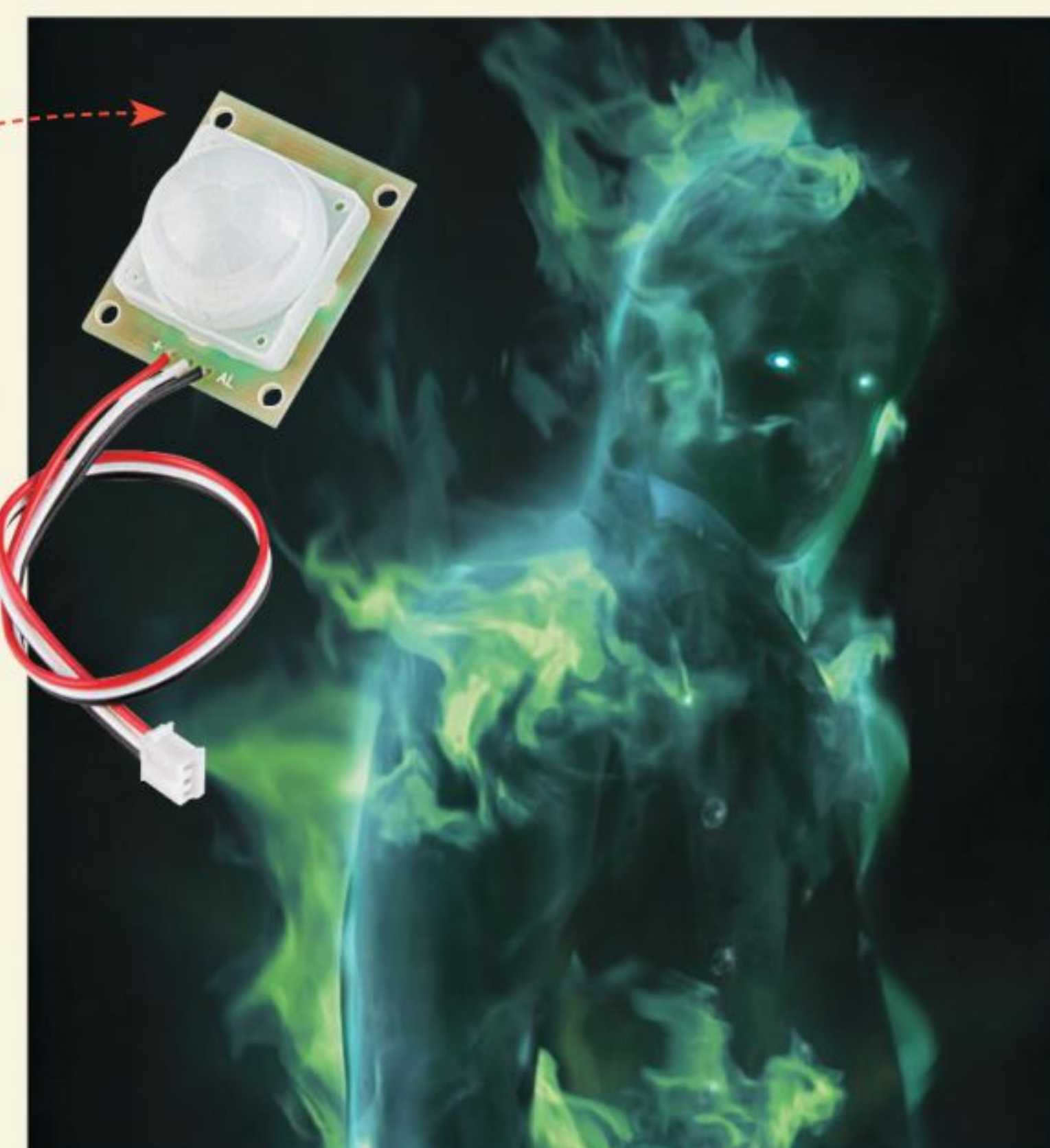
Passive Infrared

'pa-siv ,in-frə-'red

n. A method of detecting motion by observing the slight difference in radiation when one object passes in front of another



Last Halloween, radiologist George Poulos decided to make his yard extra scary. His plan: Every time a pedestrian passed by, a projector would shine a ghostly animation on a plexiglass pane to make it look like a real ghoul had appeared. It was too dark to rely on a traditional motion sensor, so Poulos used a \$10 passive infrared (PIR) one. Every object warmer than absolute zero emits infrared rays, and as one source of radiation passes in front of another, a PIR sensor detects the difference. DIYers can use PIR sensors day or night to automate security cameras, open doors for pets, help trigger Nerf sentry guns — and terrify trick-or-treaters. **R.H.**



**SAVE UP TO
50%
OR MORE ON YOUR
WINTER HEATING COSTS***

enviTM
wall-mounted room heater



- energy saving** heats room for as little as 4 cents per hour*
- easy install** installs in minutes, no drill; plugs into outlet
- ultra-safe** leave unattended 24/7; cool to the touch
- healthy** doesn't blow dust & allergens
- effective** 100% Electric; gentle whole room warmth!
- silent** fanless with auto dimming power light
- stylish** slim design, 19" wide x 22" tall x 2" thin!
- simple** easy to use thermostat; great for any room!

(*visit website for details) | **10% OFF Coupon: PS091510** | **2 or more 15% OFF Coupon: PS091515** | **Free Shipping to USA & Canada***

eheat.com 1-800-807-0107

HARBOR FREIGHT

QUALITY TOOLS AT RIDICULOUSLY LOW PRICES

How Does Harbor Freight Sell GREAT QUALITY Tools at the LOWEST Prices?

We have invested millions of dollars in our own state-of-the-art quality test labs and millions more in our factories, so our tools will go toe-to-toe with the top professional brands. And we can sell them for a fraction of the price because we cut out the middle man and pass the savings on to you. It's just that simple! Come visit one of our 600 Stores Nationwide.

SUPER COUPON

20% OFF

ANY SINGLE ITEM

LIMIT 1 - Save 20% on any one item purchased at our stores or HarborFreight.com or by calling 800-423-2567. *Cannot be used with other discount, coupon, gift cards, Inside Track Club membership, extended service plans or on any of the following: compressors, generators, tool storage or carts, welders, floor jacks, Towable Ride-On Trencher, Saw Mill (Item 61712/62366/67138), Predator Gas Power Items, open box items, in-store event or parking lot sale items. Not valid on prior purchases after 30 days from original purchase date with original receipt. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON

FREE

WITH ANY PURCHASE
CENTECH.
7 FUNCTION
DIGITAL
MULTIMETER

LOT 90899 shown
98025/69096

\$14.99
VALUE

LIMIT 1 - Cannot be used with other discount, coupon or prior purchase. Coupon good at our stores, HarborFreight.com or by calling 800-423-2567. Offer good while supplies last. Shipping & Handling charges may apply if not picked up in-store. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one FREE GIFT coupon per customer per day.

SUPER COUPON



CENTRALPNEUMATIC
**3 GALLON, 100 PSI
OILLESS PANCAKE
AIR COMPRESSOR**

LOT 95275 shown
60637/61615

\$39.99 REG. PRICE \$89.99

SAVE 55%

21688101

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**7 FT. 4" x 9 FT. 6"
ALL PURPOSE WEATHER
RESISTANT TARP**

LOT 69249/69115/69137
69129/69121/877 shown

\$3.99 REG. PRICE \$8.99

SAVE 55%

21649626

LIMIT 7 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

WOW SUPER COUPON



**12" SLIDING COMPOUND
DOUBLE-BEVEL
MITER SAW WITH
LASER GUIDE**

LOT 61776/61969/61970/69684 shown
CHICAGO ELECTRIC POWER TOOLS

\$134.33 ~~\$184.99~~ REG. PRICE \$299.99

SAVE OVER \$165

21672083

LIMIT 4 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**900 PEAK/
700 RUNNING WATTS
2 HP (63 CC) 2 CYCLE
GAS RECREATIONAL
GENERATOR**

LOT 60338/62472/69381 shown

\$99.99 REG. PRICE \$179.99

SAVE \$80

21680536

LIMIT 3 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

WOW SUPER COUPON



**44", 13 DRAWER
INDUSTRIAL QUALITY
ROLLER CABINET**

LOT 62744/69387/62270
62591/68784 shown

\$366.44 ~~\$389.99~~ REG. PRICE \$699.99

SAVE OVER \$333

21706542

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**POWDER-FREE NITRILE GLOVES
PACK OF 100**

HARDY™ MEDIUM LOT 68496/61363

• 5 mil. thickness

YOUR CHOICE! **\$6.49** REG. PRICE \$11.99

SAVE 45%

21675843

LIMIT 7 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

WOW SUPER COUPON



**RAPID PUMP® 1.5 TON
ALUMINUM RACING JACK**

PITTSBURGH AUTOMOTIVE

LOT 69252/ 60569 shown
68053/62160/62496/62516

\$59.99 ~~\$89.99~~ REG. PRICE \$119.99

SAVE \$60

21678525

LIMIT 3 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

WOW SUPER COUPON



TORQUE WRENCHES

PITTSBURGH PRO

LOT 2696/61277

\$19.99 ~~\$29.99~~ REG. PRICE \$29.99

SAVE 60%

21666355

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**12 VOLT, 10/2/50 AMP
BATTERY CHARGER/
ENGINE STARTER**

CENTECH.

LOT 66783
60581/62334
60653 shown

\$29.99 REG. PRICE \$79.99

SAVE 62%

21674329

LIMIT 4 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**45 WATT SOLAR
PANEL KIT**

THUNDERBOLT solar

LOT 62443
68751 shown

\$139.99 REG. PRICE \$299.99

SAVE \$160

21683093

LIMIT 5 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**8", 5 SPEED
BENCH MOUNT
DRILL PRESS**

CENTRAL MACHINERY

LOT 62520/62390/60238 shown

\$59.99 REG. PRICE \$129.99

SAVE \$70

21693606

LIMIT 4 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

SUPER COUPON



**80 PIECE
ROTARY TOOL KIT**

drillmaster

LOT 97626 shown
68986/69451

\$7.99 REG. PRICE \$24.99

SAVE 68%

21694214

LIMIT 6 - Good at our stores or HarborFreight.com or by calling 800-423-2567. Cannot be used with other discount or coupon or prior purchases after 30 days from original purchase with original receipt. Offer good while supplies last. Non-transferable. Original coupon must be presented. Valid through 1/15/16. Limit one coupon per customer per day.

• 100% Satisfaction Guaranteed
• Over 25 Million Satisfied Customers

• No Hassle Return Policy
• Lifetime Warranty On All Hand Tools

• 600 Stores Nationwide
• HarborFreight.com 800-423-2567

Go Ahead...

Ask Us Anything

Have a burning question?

Email it to askanything@popsci.com or tweet it to [@PopSci](https://twitter.com/PopSci) #AskAnything.

ANSWERS BY **Daniel Engber**

ILLUSTRATIONS BY **Jason Schneider**



Q: DOES COFFEE GIVE YOU A DIFFERENT BUZZ THAN TEA?

Short answer Yes, in subtle ways

A:

Eighty-nine percent of American adults regularly consume caffeine, according to the Centers for Disease Control and Prevention. Two-thirds get it from coffee, one-sixth from tea, and the rest from soft drinks. People tend to assume caffeine is the only stimulant in these beverages, but tea, and even hot cocoa, contain other compounds thought to have psychoactive effects. And their levels of stimulation vary.

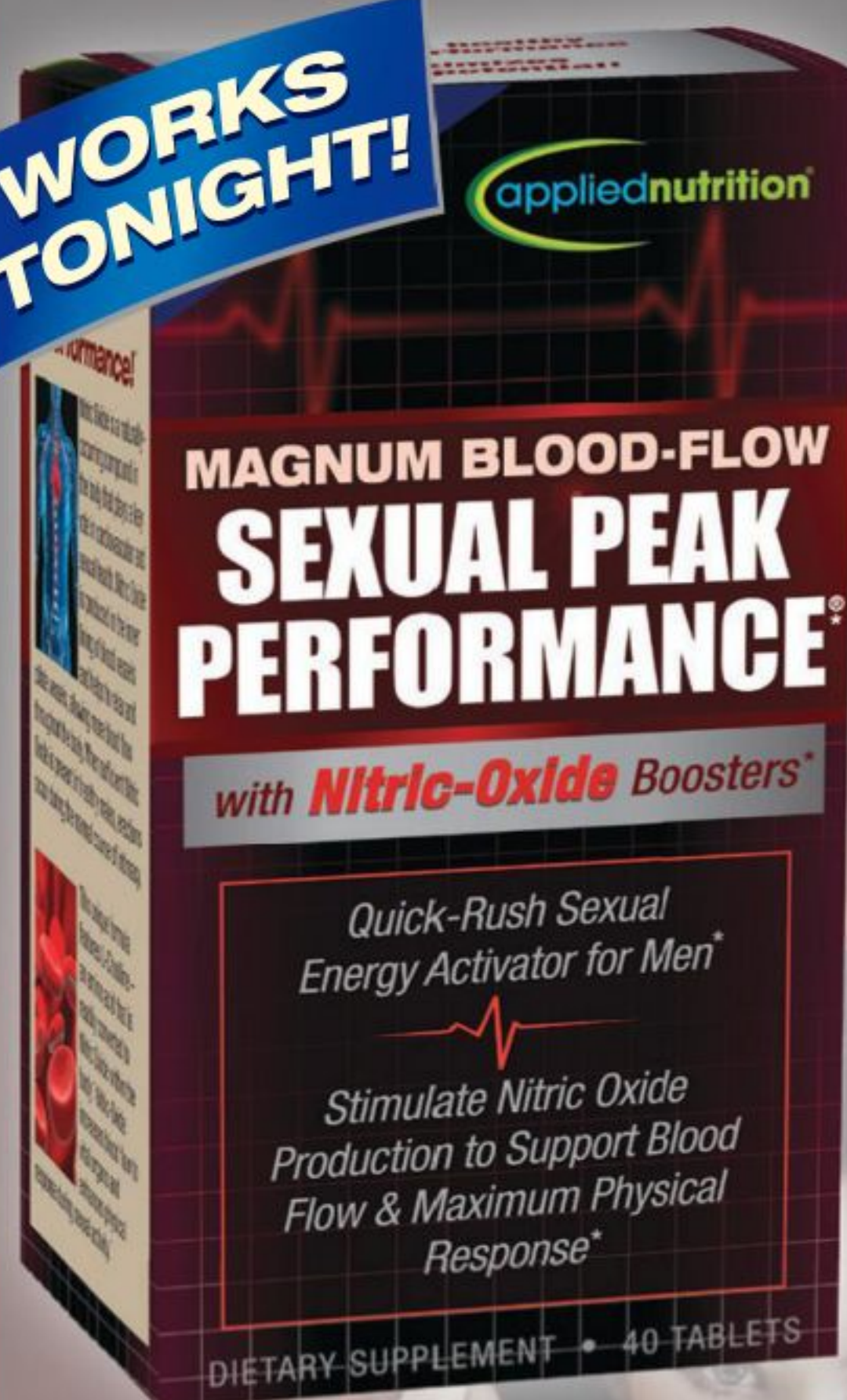
Caffeine is still the most intense stimulant. "It blows the others out of the water," says Crystal Haskell-Ramsay, a nutritional psychologist at Northumbria University in England. But caffeine doesn't act alone.

Tea, for example, contains the amino acid theanine. In 2008, Haskell-Ramsay showed that subjects who took large doses of caffeine and theanine together felt more alert than if they had taken them separately. The subjects also had better reaction time and working memory. A follow-up using smaller doses, comparable to the amount in a cup of tea, found the opposite: Theanine killed the caffeine buzz. "I think it's dose-specific," Haskell-Ramsay says.

Still, not everyone feels the same energy jolt from a given beverage. "There are genetic differences in how people respond," Haskell-Ramsay says. She, for one, avoids coffee. "It's too stimulatory for me," she says. That is, unless she's desperate. "I was at a conference once, and the tea was terrible. By day four or five, I was so caffeine-deprived, I finally bit the bullet and ordered a cappuccino."

MAXIMIZE YOUR POTENTIAL

WORKS TONIGHT!



Available for purchase with coupon in fine stores everywhere or online at:

www.appliednutrition.com

Enter Coupon Code: **012027**

Walgreens CVS/pharmacy VITAMIN WORLD

MAGNUM BLOOD-FLOW SEXUAL PEAK PERFORMANCE FOR MEN

SAVE \$3

EXPIRES 01/31/16 MANUFACTURERS COUPON

Consumer: Redeemable at retail locations only. Not valid for online or mail-order purchases. Retailer: Irwin Naturals will reimburse you for the face value plus 8 (cents) handling provided it is redeemed by a consumer at the time of purchase on the brand specified. Coupons not properly redeemed will be void and held. Reproduction by any party by any means is expressly prohibited. Any other use constitutes fraud. Irwin Naturals reserves the right to deny reimbursement (due to misredemption activity) and/or request proof of purchase for coupon(s) submitted. Mail to: CMS Dept. 10363, Irwin Naturals, 1 Fawcett Drive, Del Rio, TX 78840. Cash value: .001 (cents). Void where taxed or restricted. ONE COUPON PER PURCHASE. Not valid for mail order/websites. Retail only.



These statements have not been evaluated by the Food & Drug Administration. This product is not intended to diagnose, treat, cure or prevent any disease.

appliednutrition

Chef'sChoice®

Professional Food Slicer



Model 615

Affordable Professional Slicer

- Rugged, compact and affordable
- Professional metal food pusher
- Tilted food carriage
- Cantilever design
- Precision thickness control
- Versatile stainless steel blade slices meat, cheese, bread and more
- Easy to clean design

For the retailer nearest you, call:

EdgeCraft (800)342-3255

www.chefschoice.com

© 2015 EdgeCraft Corp. Avondale, PA 19311



How to stop paying high heating bills.

E-CLASSIC®
Outdoor Wood Furnace

With the E-Classic's efficient design and operation, you can use up to 50% less wood than traditional wood heating. How much could you save by heating your entire home, water and more with an E-Classic outdoor wood furnace?

Contact your nearest Central Boiler dealer today to find out.



*Furnace and system must be properly sized and installed.



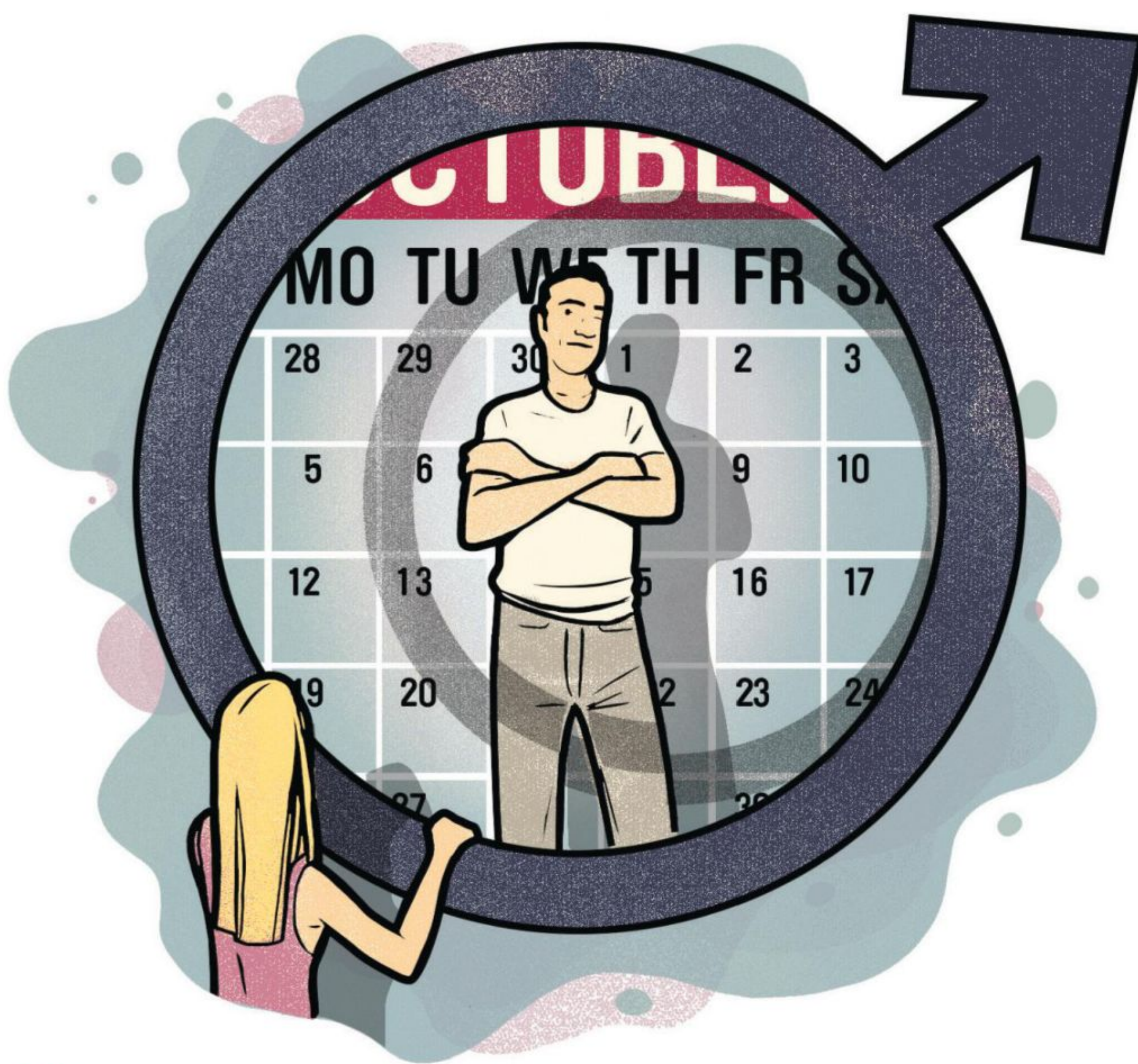
To learn about limited-time, money-saving offers and for the dealer nearest you, visit

CentralBoiler.com
or call 800-248-4681

©2015 Central Boiler • ad6897

ASK ANYTHING

OCTOBER 2015



Q:

Do men have hormonal cycles?

Short answer Ever heard of man-struation?

A:

Men do go through hormonal cycles. That much is established. Their testosterone levels tend to peak first thing in the morning, perhaps in concert with circadian rhythms, and then diminish over the course of the day—though exercise can cause fleeting spikes. What science has yet to show is whether hormones dip and rise over weeks or months, as women's do.

Some researchers believe that male hormones vary with the seasons. A 2003 study found that the testosterone levels of men in one Norwegian town bottomed out in summer and reached a high in late fall. A study of Danish men found similar seasonal variations (on a slightly different schedule). If these rhythms are real, they might have

to do with sun exposure, summer workouts, or winter weight-gain. But studies done in sunny San Diego and snowy Boston failed to replicate the Scandinavian findings. In a 2012 review, urologists at Baylor College of Medicine in Houston concluded that some "evidence exists to support the notion" of seasonal cycles but cautioned that more research was needed.

Endocrinologist Peter Celec of Comenius University in Slovakia, thinks that men have a straight-up monthly hormonal cycle too. In 2002 he published a study showing that both men and women experience roughly lunar rhythms of testosterone; the levels in men's saliva peaked dramatically on day 18 of a 30-day cycle. Celec's findings have not been replicated or accepted in the field, yet he remains convinced: "I have searched the literature for negative findings, but I have not found anything."

Celec adds that if women didn't bleed, the research establishment would likely be skeptical of their monthly cycles too.



Q: WHAT'S WITH ALL THE MOVIE MATHEMATICIANS?

Short answer A solitary genius makes for a better screenplay

A:

This year's Academy Award nominees for Best Picture included the life stories of not one but two scientists: astrophysicist Stephen Hawking (*The Theory of Everything*), and computer scientist Alan Turing (*The Imitation Game*). The fact that both men have made their breakthroughs in quantitative fields isn't serendipity. Math nerds in movies seem to be multiplying.

"We're fascinated by computability," says T. Hugh Crawford of Georgia Tech, who has written about science depictions in cinema. Figures such as Hawking and Turing can serve as heroes of the digital age. More important, they're the sort of scientists who work alone, and Hollywood loves a lone wolf, Crawford says.

The affinity for a solitary hero isn't new, but the fact that this hero can be a physicist certainly seems to be. Film

scholar George Frederick Custen found that only 6 percent of the 291 biopics released between 1927 and 1960 were science-themed; almost half of those told the stories of clinicians—nurses, doctors, even a dentist. Most of the rest depicted inventors, such as Alexander Graham Bell and Thomas Edison, or lab researchers like Louis Pasteur and Marie Curie.

Early science biopics portrayed the nitty-gritty reality of working as a chemist or bacteriologist. "Ninety percent of the Marie Curie film is just showing the rote difficulty of doing lab practice," Crawford says. Recent biopics have taken a different approach, choosing instead to feature mathematicians or theoretical physicists, whose work can be imagined (and even misrepresented) as a series of Eureka moments. But one thing these scientists all have in common: love interests. Ah, Hollywood. *P/s*



Laser Measured, Custom-Fit
FloorLiner™

Available in Black, Tan and Grey

WeatherTech®

American Manufacturing Done Right!



Cargo/Trunk Liner



All-Weather Floor Mat



Side Window Deflectors

Designed in USA - Handcrafted in Germany



CargoTech®
Keeps Cargo Stable

Accessories Available for

Acura • Audi • BMW • Buick • Cadillac • Chevrolet • Chrysler • Dodge • Ferrari • Ford • GMC • Honda • Hummer • Hyundai • Infiniti • Isuzu • Jeep • Kia • Land Rover • Lexus • Lincoln • Maserati • Mazda • Mercedes-Benz • Mercury • Mini • Mitsubishi • Nissan • Oldsmobile • Plymouth • Pontiac • Porsche • Saab • Saturn • Scion • Subaru • Suzuki • Toyota • Volkswagen • Volvo • and more!

Order Now: **800-441-6287**



American Customers
WeatherTech.com



Canadian Customers
WeatherTech.ca



European Customers
WeatherTechEurope.com

K-band false alarms driving you nuts?

The problem: Barraged by K-band false alarms lately? Seems like they're everywhere, and they hang *on* and *on*.

What changed? A new safety feature, the lane-change, or blind-spot, warning often uses K-band radar to "see" nearby cars.

V1 has the solution

The old problem of K-band door-openers was self-limiting. Buildings don't move. You're soon out of range. But a blind-spot system may tag along with you for miles. You're stuck, not knowing which car to maneuver away from.

Introducing Junk-K Fighter: It recognizes these junky false alarms and excludes them. And it's now built into all new V1s.

We can build one for you. Try it for 30 days. If it doesn't satisfy for any reason, send it back for a full refund.



NEW: Computerized Junk-K Fighter analyzes and rejects most blind-spot warning systems.



www.valentine1.com

Valentine One
RADAR LOCATOR

Valentine Research, Inc. Ph 513-984-8900
Department No. YG05 Fx 513-984-8976
10280 Alliance Road
Cincinnati, Ohio 45242



Call toll-free 1-800-331-3030

- ☐ Valentine One Radar Locator with Laser Detection - \$399
- ☐ Carrying Case - \$29 ☐ Concealed Display - \$39
- ☐ V1connection™ - \$49 ☐ V1connection™ LE - \$49
- ☐ SAVVY® - \$69 Plus Shipping / Ohio residents add sales tax

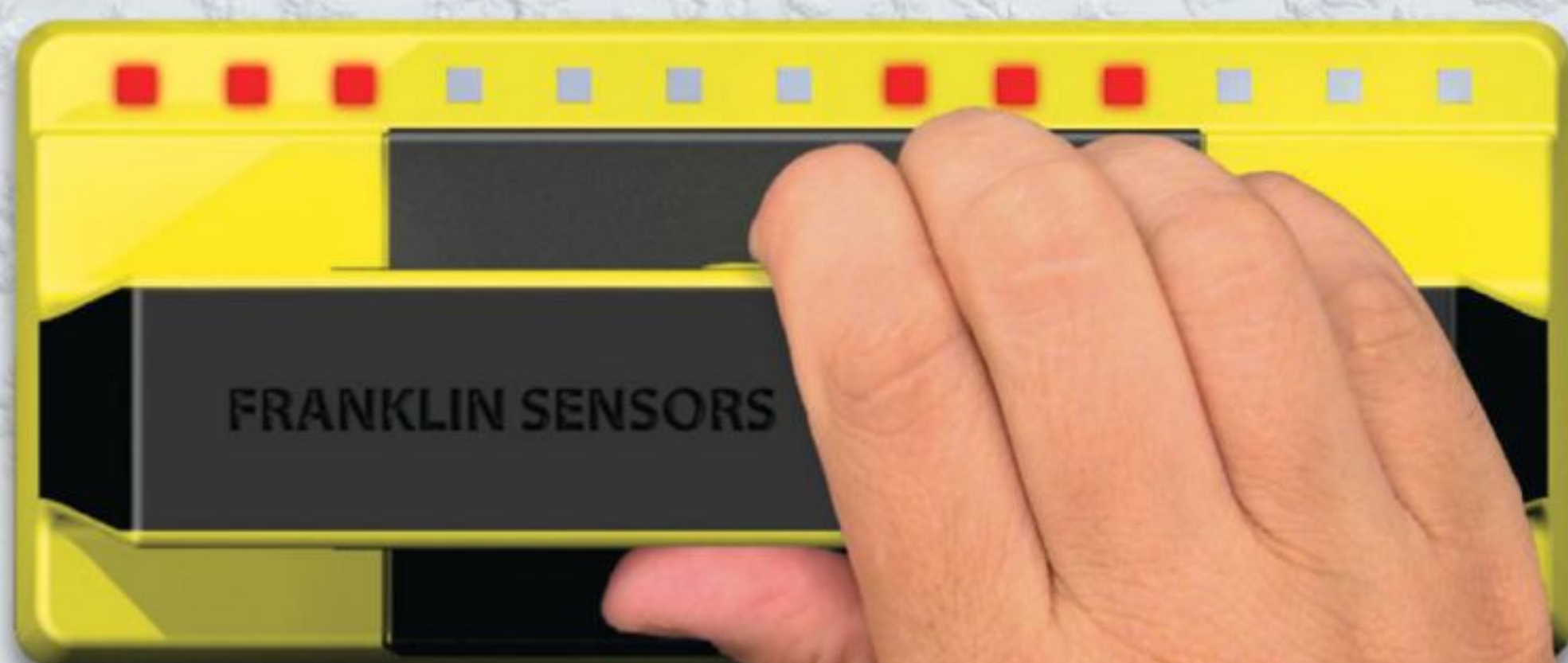
30-Day Money-Back Guarantee

Valentine One is a registered trademark of Valentine Research, Inc.

©2015 VRI

Mike Valentine
Radar Fanatic

Finding Studs Just Got A Lot Easier.



- **Highest accuracy stud finder**
- **Easy to use**
- **Find studs quickly and easily**

The **Franklin Sensors ProSensor 710** has innovative stud sensing technology that instantly finds hidden studs. No sliding is required. It senses the wall in thirteen locations simultaneously, then immediately illuminates the LED lights in front of the stud. The ProSensor 710 is the fastest, least error prone, and most accurate stud finder on the market. It's the easy way to find studs.

www.franklinsensors.com

**FRANKLIN
SENSORS**
PROFESSIONAL STUD FINDERS

OCTOBER 2015

The Brilliant 10

CONTINUED FROM PAGE 52



reducing farmers' herds—from nine sheep per hectare to six—prevented swarms from forming. Another benefit: The lower grazing density boosted the farmers' bottom lines by yielding heftier animals.

Cease is now working with government agencies in all three countries where she has projects—Senegal, China, and Australia—to identify practices that might help stop swarming, such as paying farmers not to overgraze. Traditional locust management involves attacking swarms as they form—a stop-gap solution at best. "We are trying to keep locusts at bay in the long term," she says.

DAVID KIPPING

Hunts for Moons Around
Exoplanets / **AGE:** 31

In graduate school, David Kipping was hiking in the Himalayas when, staring up at the sky, he thought about how exoplanets are found—by detecting the change in brightness as it passes in front of a star. How would an exoplanet be affected if it had a moon, he wondered? His quest for an answer led him to pioneer a new field of study.

Kipping, now an astrophysicist at Columbia University, has developed a novel method to seek out exomoons. He and his colleagues sift through data from the Kepler telescope, and when they spot a promising exoplanet, they develop a mathematical model of what its orbit would look like if it had a moon pulling on it. They then compare that to orbital data. The sensitivity of the method should reveal satellites big enough to have an atmosphere and warm enough to support life. It could be that Earth-like moons are more common than Earth-like planets, which have turned out to be surprisingly rare. "It's actually quite plausible that we are the freaks of the universe living on a planet, and that most life lives on a moon," Kipping says.

At first, colleagues were skeptical that searching for exomoons was a good use of time. But since his first paper on the subject, others have joined the hunt. No exomoons have been found yet—Kipping's group ruled out 60 planets so far, and he hopes to look at 300 more in 2016. But if one of those candidates pans out, it could answer important questions about where moons come from and how planets form—and even inform the search for life beyond our solar system. *P/s*

IN THE TIME
IT TOOK SOME
@#%!
TO SCRATCH IT,
FIX IT.



In about the same time it took you to have your car scratched at the grocery store, our online videos will show you how to tackle almost any repair.



Paint pens >>> ½ oz & 2 oz bottles
12 oz spray cans >>> Ready-to-spray pints, quarts and gallons

AUTOMOTIVETOUCHUP.COM
888-710-5192



*The most expensive Mercedes-Benz® ever made.
Rarer than a Stradivarius violin.*

Not actual size.
Shown is model in Pearl White finish.
Also available in Ruby Red finish.

How to Park \$11.7 Million on Your Desktop

The 500K Special Roadster is one of rarest and most-sought after automobiles ever built.

It's hard to deny that one of the signature models of Mercedes-Benz® is the 500 series. So many striking and elegant bodies would grace the stalwart chassis. The 500K's of the 1930s were beautiful, elegant, and exclusive models often outfitted with voluptuous coachwork and sold to the wealthiest of clientele.

The most ravishing model of this species was the two-seater 500K Special Roadster launched in 1936. It was a limited production cabriolet, in total less than 30 were made, adding to its near-mythical qualities. In its day it went for top dollar—over \$106,000. Today, these ultra rare masterpieces are going for millions. In 2012, a Special Roadster fetched more than \$11.7 million at auction at the Pebble Beach Concours d'Elegance.



Die-cast metal body features doors, hood and trunk that open, steerable wheels that roll, and four wheel suspension. Available in Ruby Red finish.

Our die-cast metal replica captures the sexy curves and sumptuous coachwork of the full-size model in striking detail. Just shy of a foot long, and available in pearl white or ruby red. You don't need to spend millions to showcase your impeccable taste. Sold! To the discerning reader for \$99!

Your satisfaction is 100% guaranteed. Test drive the Special Roadster for 30 days. If for any reason you are not completely satisfied, simply return it to us for a full refund of your purchase price. But we're sure that once you park this beauty in your house you'll be sold.

Comes factory sealed in its original packaging in order to retain its status as a highly collectable item.

1936 Mercedes-Benz® 500K Special Roadster

(Pearl White or Ruby Red finish) ~~\$149†~~

Offer Code Price **\$99** + S&P **Save \$50**

1-888-201-7081

Your Insider Offer Code: MBD197-01

You must use this insider offer code to get our special price.

High-quality 1:18 scale die-cast replica • intricate moving features
• Detailed chassis with separate exhaust systems • Includes display stand

† Special price only for customers using the offer code versus the price on Stauer.com without your offer code.

Stauer® 14101 Southcross Drive W., Dept. MBD197-01
Burnsville, Minnesota 55337 www.stauer.com



ATHENA PHEROMONES™ INCREASE AFFECTION



Created by
Winnifred Cutler,
Ph.D. in biology from
U. of Penn, post-doc
Stanford.
Co-discovered human
pheromones in 1986
(Time 12/1/86; and
Newsweek 1/12/87)
**10X increases
your attractiveness**

PROVEN EFFECTIVE IN 3 DOUBLE BLIND STUDIES



Unscented
Fragrance Additives

Vial of 1/6 oz. added to 2-4 oz. of
your fragrance, worn daily lasts
4-6 months, or use it straight.

Athena 10X™ For Men \$99.50
10:13™ For Women \$98.50
Cosmetics **Free U.S. Shipping**

♥ **Eddie (FL)** 78 orders. "I would like to get
another 2 vials sent priority. Believe me, 10X still
works! Yesterday I was at the post office
standing just behind the entrance door, when
a woman walked in past me and turned
around. She said, 'You smell so good, I can't
stand it!!!' I get so many comments... *Don't
ever stop making it, Doc!*" Rec'd 2/11/15

Not in stores  610-827-2200

www.Athenainstitute.com

Athena Institute, 1211 Braefield Rd., Chester Springs, PA 19425 PS

RotoCube.com® Rotating Whiteboard Bulletin Tower

Share information where people gather.



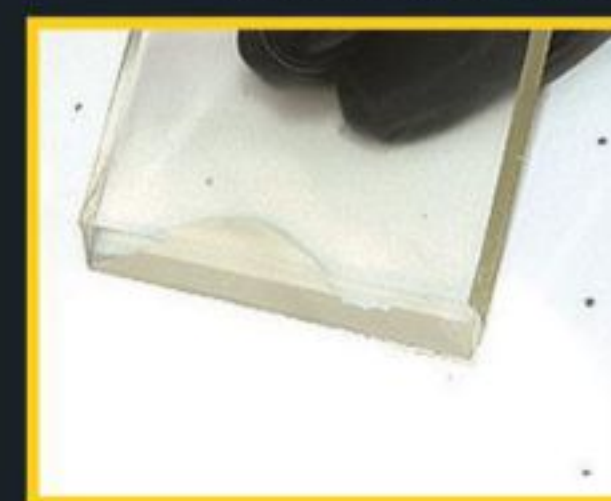
RotoCube.com



YOUR PAINT'S WORST ENEMY HAS MET IT'S MATCH...

SQUIRT

SQUIRT OUT A FEW
DROPS OF THE OEM-
MATCHED PAINT



SQUEEGEE

USING THE SPECIAL
SQUEEGEE, SMEAR THE
PAINT INTO THE CHIPS

BLEND

SEALACT BLENDS
THE EXCESS PAINT



PERMANENT REPAIRS
IN JUST MINUTES,
NOT HOURS!



SQUIRT N SQUEEGEE KIT IS
THE FAST, SIMPLE, DRAMATIC
WAY TO REPAIR PAINT CHIPS -
WITH NO PAINT BLOBS!

ORDER YOUR KIT TODAY -

REPAIR KITS
AVAILABLE
IN 4 SIZES
FROM \$39.95



**RATED #1 BY THE
WALL STREET
JOURNAL**

DR. COLORCHIP™
AUTOMOTIVE PAINT CHIP REPAIR SYSTEMS

DRColorChip.com • 866.372.2548

What Are You Raking For?



Make Fall Cleanup Easy

**Learn More
REQUEST A FREE
INFORMATION KIT**

Call: **1-800-605-3639**
or Visit: **CycloneRake.com**

Use Promo Code **PS1015** when you call,
or enter it on our website for a special offer on any Cyclone Rake purchased by 12/30/2015.

MATHTUTORDVD
Press Play For Success

Having Math Problems?



Earn A's with Ease

Get Help Now!

Basic Math
Pre-Algebra
Algebra thru Calculus
Differential Equations
Physics
Chemistry
Probability/Statistics
Calculator Tutorials

*Begin Learning
in Minutes!*
MathTutorDVD.com

✓ Raise grades or your money back
✓ Award Winning Courses
✓ Money Back Guarantee
Order By Phone: 877-MATH-DVD

View all courses online or order DVDs at:

MathTutorDVD.com

CAPTURE THE WILD WEST

MORGAN SILVER DOLLARS

The Most Widely Collected U.S. Silver Coin

Minted from 1878-1921, Morgan Silver Dollars were a mainstay of 19th and early 20th century commerce. The Morgan Silver Dollars in this special release are over 100 years old, in very good or better condition and contain over 3/4 of ounce of pure silver. Perfect for individuals wanting to add historic U.S. silver coins to their collection. For the discerning collector, a limited amount of Brilliant Uncirculated Morgan Silver Dollars will be made available at a special introductory price.



\$26.95 ea

NO DEALERS PLEASE

VERY GOOD CIRCULATED CONDITION
DATES OF OUR CHOICE 1878-1904

15 DAY MONEY BACK GUARANTEE!

100% satisfaction guaranteed, if for any reason you are not happy with your purchase then return it up to 15 days after receipt of order for a prompt refund.

Metal Content: ----- 0.7734 troy oz
Purity: ----- .900
Manufacturer: ----- United States Mint
Thickness: ----- 3.1 mm
Diameter: ----- 38.1 mm



**COIN SPECIALISTS
STANDING BY 24/7**

www.Aerlooms.com

VAULT CODE: PSMSD-1015

(2646)
1-877-227-COIN

CHECK OR MONEY ORDER



Coins shown are not actual size. Limit 20 silver coins per household. Price plus shipping. No sales tax on gold and silver purchases. Prices subject to change without notice. Availability not guaranteed. New customers only. No dealers please. American Eagle Reserve is not affiliated with the U.S. Government.

WHITEWALLS® MAGNETIC WHITEBOARD STEEL WALL PANELS

WhiteWalls® give you and your team an blank slate that encourages original ideas and fosters out of the box solutions.



WhiteWalls.com

Call- 800 624 4154

LOWEST PRICE EVER on DR® Leaf Vacuums!

- Rated #1 in Vacuum Power
- Easy, 1-Hand Dumping
- Stores Flat in Minutes
- Converts to a Utility Trailer



FREE SHIPPING 1 YEAR TRIAL

SOME LIMITATIONS APPLY

Call for **FREE DVD and Catalog!**

TOLL FREE **888-213-1330**

DRleafvac.com



89029X © 2015

www.motionmodels.com

THE WORLDS FINEST READYMADE AND CUSTOM TRUE MUSEUM QUALITY AIRPLANE AND NAVY AND COAST GUARD SHIP MODELS



WE CAN CUSTOM MAKE MOST COAST GUARD SHIPS AND PLANES
USCGC CHASE
WHEC 718
PICTURED



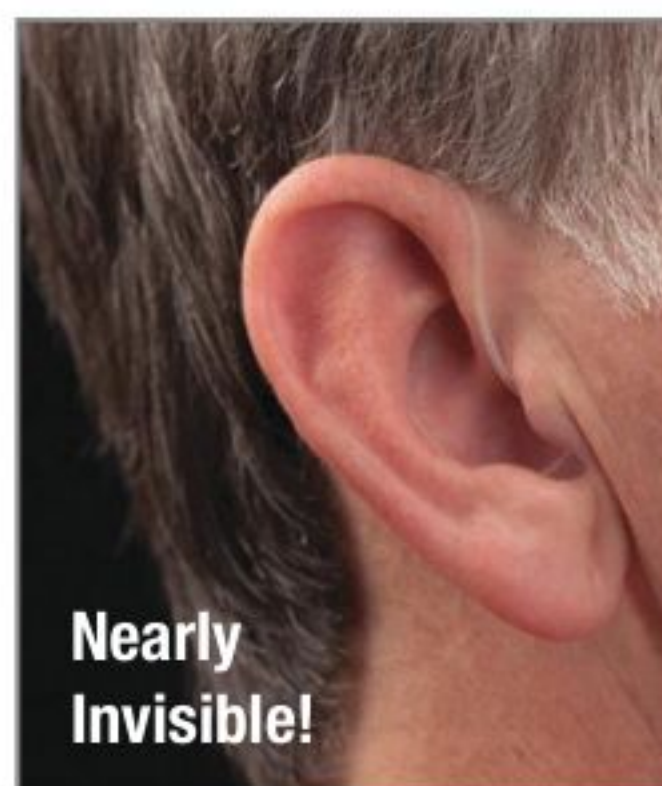
WE CAN CUSTOM MAKE MOST NAVY SHIPS AND PLANES
CVN-77 THE USS
GEORGE H.W. BUSH
MADE FOR PRESIDENT BUSH



www.motionmodels.com
1-800-866-3172

TINY NEW AFFORDABLE HEARING AID

The MDHearingAid® **AIR** is doctor designed and delivers the same hearing experience as devices costing thousands of dollars for 90% less. This FDA-Registered, state-of-the-art digital hearing aid provides crystal clear, natural sound — in a crowd, on the phone, in the wind — without “whistling” or annoying background noise. **Call today for a 45-Day, Risk-Free trial with a 100% money-back guarantee and get FREE batteries for a full year.**



Nearly Invisible!

Call 800.873.0541
with offer code **CE92** or visit
MDHearingAid.com

5-Minute Fence Stain



- Stain 100 ft of fence in just 5 minutes!
- Sprayer attaches directly to garden hose.
- No masking, simply hose off over-spray.
- One quart covers 600 square ft.
- Select from three natural wood tones; Natural Cedar, Dark Cedar or Redwood.

FiveMinuteFence.com

HELLO DESIGN, MEET SEXY.



THE ESSE CHAISE

Beds are for sleeping. The Esse Chaise is for everything else. Discover what your sex life has been missing at **liberator.com**

LIBERATOR
BEDROOM ADVENTURE GEAR

Dive Bar T-shirts



DIVE BAR

SHIRT CLUB

Sorry, We're OPEN

Join the Club!

You'll get a new T-shirt every month from the best bars you've never heard of!

DiveBarShirtClub.com



DONT LET PHOTO TICKETS DRAIN YOUR WALLET

License plate cover that prevents photo tickets!

- 100% Effective
- No-Ticket Guarantee
- Easy 30 Second Install
- Works against all speed & red light photo cameras!

www.PhotoMaskCover.com

(877) 992-9688

SPECIAL OFFER!

Purchase your PhotoMaskCover today and use discount code SCI5 for a 5% discount.

Order now to take advantage of our limited time FREE shipping this month!

PARTS EXPRESS
YOUR ELECTRONICS CONNECTION

FREE CATALOG
Over 18,000 audio/video products

For more information and a special offer visit:
parts-express.com/pop

1-800-338-0531

MEN'S WIDE SHOES

FREE catalog
200+ styles

EEE-EEEEEE, SIZES 5-20

www.wideshoes.com

1-800-992-WIDE • Hitchcock Shoes
Dept. 46T5 Hingham, MA 02043

A UNIVERSAL LIFT FRAME

Why spend a fortune for a lift chair?
Enhansit simply attaches to the bottom of your favorite recliner in minutes, making your favorite, comfortable recliner a Lift Chair quickly and easily.

Easy as 1-2-3
Check Website for Specials!

www.enhansit.com
1-888-217-1211

Underbed Dressers

Put Up to 24 Drawers
Under Your Beds

ultimatebed.com

FREE

All you need to know about the Bible for Salvation.
[http:// aboutsalvation.blogspot.com/](http://aboutsalvation.blogspot.com/)
Free CD, About Salvation.
P.O. Box 156 Wartburg, TN 37887-0156

SOON THE GOVERNMENT
will enforce the "MARK" OF THE BEAST as
CHURCH and STATE unite!
OFFER GOOD IN USA ONLY

Need your mailing address for FREE BOOKS /DVDS
TBSM, Box 99, Lenoir City, TN 37771
thebiblesaystruth@yahoo.com. 1-888-211-1715.

GOLD/JEWELRY

KINEKT
INTERACTIVE JEWELRY

GEAR RING &
GEAR NECKLACE

FREE SHIPPING & LIFETIME WARRANTY
kinektdesign.com | 888-600-8494

THE NINE PLANETS RING

HANDCRAFTED WITH AN ORBITING
GIBEON METEORITE BAND
IN 18K GOLD SET WITH 9 GEMSTONES

JEWELRYDESIGNSFORMEN.COM
831.336.1020

HEALTH & FITNESS

GOT WARTS?
Electronic Wart Remover
100% successful home treatment
(800) 645-0234
www.wartabater.com

NAME BRAND HEARING AIDS
60% SAVINGS

- All Makes & Models • Free Catalog
- Ranging from Analog to Ultimate Digital
- 45 Day Home Trial • 50 Yrs Experience

LLOYD HEARING AID
1-800-323-4212 www.lloydhearingaid.com

UNCLOG DRAINS
with your
Pressure Washer

Works on your
Money Back
Visit store for details

\$10 OFF
GIFT CODE: PS44 LIMITED TIME

ClogHog.com
877.992.5644

OF INTEREST TO MEN

WHERE SINGLES MEET
Browse Ads & Reply Free!
1-888-634-2628
Use FREE Code 3185, 18+

POND & LAKE MANAGEMENT

LAKE OR POND? Aeration is your 1st step toward improved water quality. Complete Systems \$169 - \$369. Waterfall? - 11,000gph Water Pump only 3.6 amps! 2yr warranty! Just \$399.95 www.fishpondaerator.com 608-254-2735 ext. #3

Pre-Assembled - Installs in Minutes!

CasCade 5000
Floating POND FOUNTAIN!
Aerator
Now Available Factory Direct!
MSRP (\$1100) You Pay \$698.95!
Complete with light & timer,
100 ft power cord, 1yr warranty!
(Also available in 3/4hp & 1.25hp)

1hp unit shown
Call 7days/week! FAST UPS shipping right to your door!
(608) 254-2735 www.fishpondaerator.com

WATER PURIFICATION

BEST DRINKING H2O!

Doppler Ultra Sound tests
at any Hospital PROVES it!

FREE Bottled Water SAMPLE!
570.296.0214

WATER REPORT SCAM! - One of 5 companies cited by The Consumer Product Safety Commission! American Cancer Society founder at my home 50 yrs ago: "Help the American people by recycling water 100's of times/gallon (NOT once!) to destroy deadly viruses that also travel with steam and survive boiling!" 13 Patents, 332 FDA Tests, at 85 this works!

VIDEO PROOF:
This increase in
ENERGY CAN
CHANGE YOUR LIFE!

800 433-9553

johnellis.com/RonaldReaganStory

From the Archives

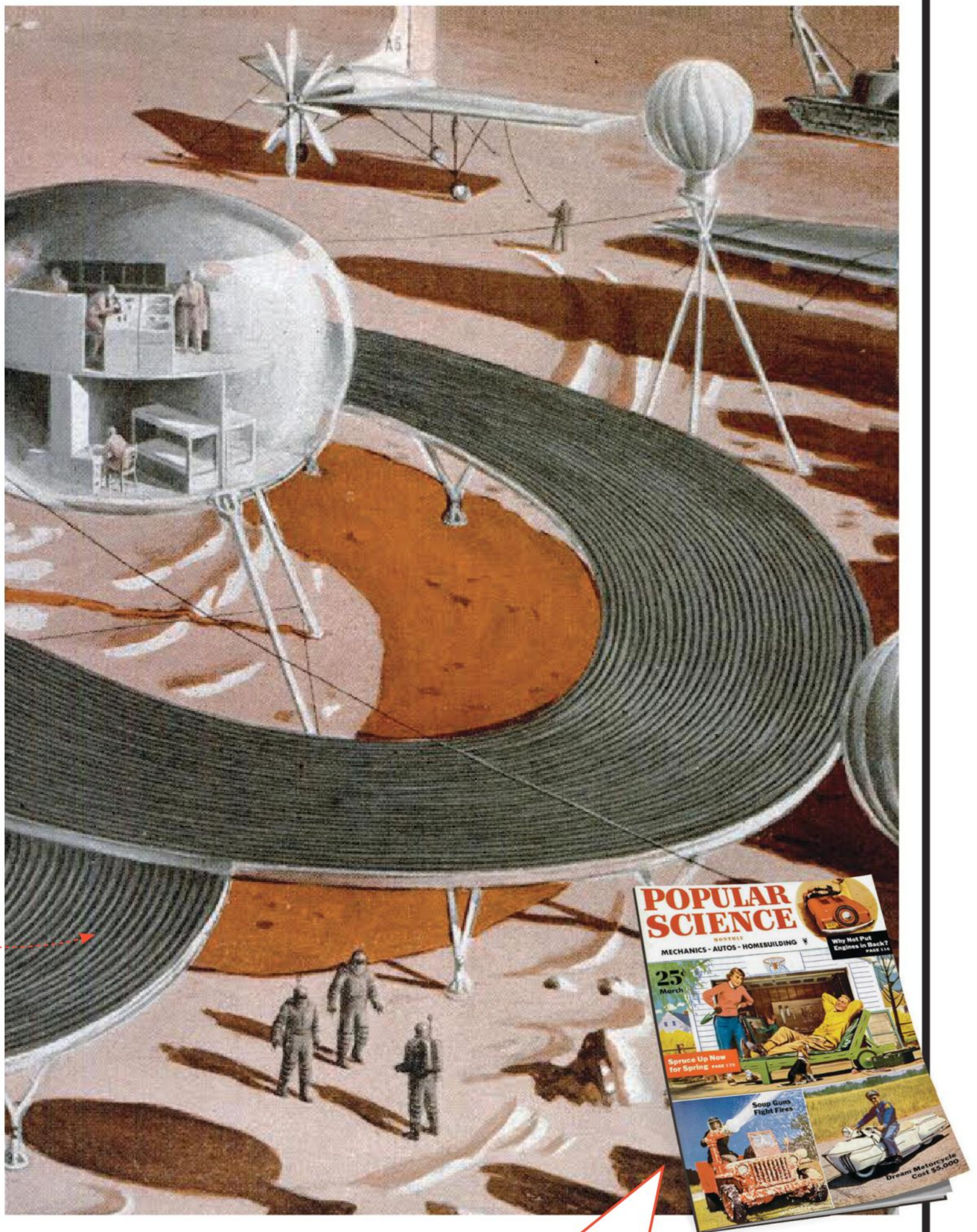
A RED PLANET TO CALL HOME



In 1953, people had yet to see a close-up image of Mars. But that didn't dim the prospect of one day living there. In March of that year, *Popular Science* featured a plan—developed by a graduate student with the input of government scientists—outlining how 33 earthlings might one day live on the Red Planet. Their spaceship would serve as the base's hub. A heart-shaped ring of solar panels would warm the living quarters, and wind generators would provide power. And alien invaders? There was a plan for them too. Decontaminating mist would kill any Martian germs clinging to the crew's space suits as they entered the base. Today, life on Mars is still the subject of avid speculation. The producers of *The Martian*, a film to be released in theaters October 2, also consulted government scientists to bring their vision to the big screen. For more from director Ridley Scott, turn to page 42. **REBECCA HARRINGTON**

08

Length of time, in months, it would take humans to travel to Mars today



“And so the initial landing on Mars must necessarily be an adventure fraught with the utmost peril. But if history repeats itself, there will be no dearth of volunteers, prepared to gamble their lives to advance the frontier of human knowledge.” — *POPULAR SCIENCE*, MARCH 1953

POPULAR SCIENCE magazine, Vol. 287, No. 4 (ISSN 161-7370, USPS 577-250), is published monthly by Bonnier Corp., 2 Park Ave., New York, NY 10016. Copyright ©2015 by Bonnier Corp. All rights reserved. Reprinting in whole or part is forbidden except by permission of Bonnier Corp. Mailing Lists: We make a portion of our mailing list available to reputable firms. If you would prefer that we not include your name, please write to POPULAR SCIENCE, P.O. Box 6364, Harlan, IA 51593-1864. POSTMASTER: Send address changes to POPULAR SCIENCE, P.O. Box 6364, Harlan, IA 51593-1864. Periodicals postage paid at New York, NY, and additional mailing offices. Subscription Rates: \$19.95 for 1 year. Please add \$10 per year for Canadian addresses and \$20 per year for all other international addresses. Canada Post Publications agreement #40612608. Canada Return Mail: IMEX Global Solutions, P.O. Box 25542, London, ON N6C 6B2. Printed in the USA. Subscriptions processed electronically. Subscribers: If the post office alerts us that your magazine is undeliverable, we have no further obligation unless we receive a corrected address within two years. Photocopy Permission: Permission is granted by POPULAR SCIENCE® for libraries and others registered with the Copyright Clearance Center (CCC) to photocopy articles in this issue for the flat fee of \$1 per copy of each article or any part of an article. Send correspondence and payment to CCC (21 Congress St., Salem, MA 01970); specify CCC code 0161-7370/85/\$1.00-0.00. Copying done for other than personal or reference use without the written permission of POPULAR SCIENCE® is prohibited. Address requests for permission on bulk orders to POPULAR SCIENCE, 2 Park Ave., New York, NY 10016 for foreign requests. Editorial Offices: Address contributions to POPULAR SCIENCE, Editorial Dept., 2 Park Ave., New York, NY 10016. We are not responsible for loss of unsolicited materials; they will not be returned unless accompanied by return postage. Microfilm editions are available from Xerox University Microfilms Serial Bid Coordinator, 300 N. Zeeb Rd., Ann Arbor, MI 48106.

Saving People Money Since 1936

**... that's before there were
personal computers.**

GEICO has been serving up great car insurance and fantastic customer service for more than 75 years. Get a quote and see how much you could save today.

geico.com | 1-800-947-AUTO | local office

GEICO®



TEETH MARKS

**IF EXPERTS CHOOSE GOODYEAR® FOR SUPERIOR
TRACTION, WHAT'S STOPPING YOU?**

Learn more at Goodyear.com

Goodyear.com ©2015 The Goodyear Tire & Rubber Company. All rights reserved.

GOODYEAR 
MORE DRIVEN.